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A STUDY OF THE SHIPMENT OF FRESH FRUITS AND VEGETABLES TO THE FAR EAST

E. L. OVERHOLSER[1]

Because of the distance to markets, California growers and handlers of fruits and vegetables are greatly dependent upon refrigeration in some form for the successful marketing of these perishable crops. Recently the fruit growers and allied interests in their efforts to develop foreign markets for California fruits have desired information concerning the response of perishable agricultural commodities to marine refrigeration. The conditions in the low-temperature compartments on board ship are different from those surrounding perishables under refrigeration on land, and less is known about them. The preliminary studies reported herewith were made in an attempt to obtain information that may be helpful in the proper utilization of ship refrigeration in the future marketing of California's perishable crops.

INVESTIGATIONS UNDERTAKEN AND EXPERIMENTAL CONDITIONS

The investigations conducted were divided into three phases of study: (1) The conditions surrounding the cargo stowed in the refrigerated hold; (2) the response of the experimental cargo; and (3) in the ports visited, the requirements to be met before the cargo is admitted, and the facilities for handling and temporary retention of the perishable cargo.

The experiments were conducted upon the motor vessel Silverhazel, a ship of about 10,000 tons capacity. The ship is provided with four refrigerated compartments, in No. 4 hold: (1) the forward lower hold chamber with a capacity of 15,177 cubic feet; (2) the aft lower hold, 15,885 cubic feet; (3) the forward 'tween deck chamber, 10,442 cubic feet; and (4) the aft 'tween deck, 10,916 cubic feet. The total capacity is a little over 52,000 cubic feet.

The refrigeration is furnished by an electrically driven carbon-dioxide compressor. Air is chilled by passing over batteries of brine coils, and then driven through ducts to the refrigerated compartments. In the case of the 'tween decks, the chilled air passes into the

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compartments through openings in the ducts on one side, and is forced and drawn across the compartments to the opposite side into return ducts and thence back to the brine coil room. During the experiments the air passed in one direction only and the currents were not reversed. With the exception of short intervals of time the air was in continual circulation.

With the two lower holds, the cold air is forced into the compartment from below through numerous holes in the floor and drawn out at each side through openings in the ducts on the starboard and port sides and thus returned to the bunker of brine coils.

AIR AND SEA TEMPERATURES ENROUTE

It is of interest to steamship operators and to fruit exporters, as well as of significance in its possible relation to the experiments conducted, to have presented for the duration of the experiments daily average temperature records of the air, of the surface water of the sea, and of the sea water at a depth of 18 feet. These records were obtained every four hours, and hence each day's average is of six observations. The air temperatures were taken in three different positions upon the ship—the navigation bridge, the laboratory on the aft boat deck, and on the main deck just forward of the hatches of the refrigerated hold. The data are given in table 1.

The lowest average air and sea temperatures were encountered between 2,500 and 3,000 miles northwest of San Francisco, south and southwest of the Aleutian Islands, in the vicinity of the 180th meridian. These temperatures averaged about 50° to 55° F. From Manila southward and to as far as Singapore, the termination of the test trip, the temperatures averaged much higher, from 80° to 93° F.

The temperature of the surface sea water tended to be slightly cooler than the air in the temperate climate during the trip. In the subtropical and tropical regions, however, the temperatures of the surface sea water were usually appreciably cooler than the air temperatures. There was a close agreement, however, between the shade temperatures of the open air and the surface sea water temperatures throughout the long voyage at sea.

One striking thing was that the temperature of the sea water 18 feet below the surface, as measured by the ship's thermometers, tended to be warmer than the surface water. In the tropics the sea temperatures at a depth of 18 feet were occasionally higher than the air temperatures, which seldom happened with the sea temperatures at the surface.

TABLE 1

THE AVERAGE AIR AND SEA TEMPERATURES ENROUTE DURING THE EXPERIMENTAL TRIP

Daily averages of observations at 4-hour intervals.

Date	Position	Average daily temperatures		
		Air	Surface water	Sea water at depth of 18 ft.
		°F	°F	°F
Sept. 14	69 miles northwest of San Francisco	59.2	60	63
Sept. 15	424 miles northwest of San Francisco	60 0	60.5	64
Sept. 16	764 miles northwest of San Francisco	62.0	62.8	67
Sept. 17	1,074 miles northwest of San Francisco	59.7	59.0	66
Sept. 18	1,362 miles northwest of San Francisco	61.4	60.1	63
Sept. 19	1,690 miles northwest of San Francisco	64.4	62.0	63
Sept. 20	2,008 miles northwest of San Francisco	60.4	60.0	64
Sept. 21	2,342 miles northwest of San Francisco	57.7	55.8	58
Sept. 22	2,628 miles northwest of San Francisco	53.4	53.3	56
Sept. 24	2,868 miles northwest of San Francisco (180th meridian)	53.3	53.1	55
Sept. 25	3,088 miles northwest of San Francisco	54.1	53.0	55.5
Sept. 26	3,437 miles northwest of San Francisco	58.8	58.5	58.5
Sept. 27	3,772 miles northwest of San Francisco	66.1	65.1	68.0
Sept. 28	4,065 miles northwest of San Francisco	70.1	69.8	74 0
Sept. 29	4,393 miles northwest of San Francisco	75.0	73.3	74 0
Sept. 30	4,571 miles from San Francisco (Yokohama, Japan)	69.3	70 0	72.0
Oct. 1	38 miles south of Yokohama	69.6	71.7	73.5
Oct. 2	345 miles south of Yokohama at Kobe, Japan	70.2	72.5	74 5
Oct. 3	Kobe, Japan	72.2		73 0
Oct. 4	Kobe, Japan	73.6	73.0	75 0
Oct. 5	239 miles south of Kobe, Japan	76.5	75 6	80.0
Oct. 6	594 miles southwest of Kobe, Japan	76.6	74.7	79 0
Oct. 7	772 miles southwest of Kobe, at Shanghai, China	73.0		76 0
Oct. 8	Shanghai, China	80 0		77.0
Oct. 9	Shanghai, China	80 4		76 5
Oct. 10	Shanghai, China	80.1		76.0
Oct. 11	25 miles from Shanghai, China	70.1	72.5	74.5
Oct. 12	373 miles south of Shanghai	76.6	75.2	80.5
Oct. 13	726 miles south of Shanghai	80.0	79.5	83.0
Oct. 14	1,058 miles south of Shanghai	83.4	81.5	85.0
Oct. 15	1,133 miles south of Shanghai, at Manila, P. I.	86.0		84.0
Oct. 16	Manila, P. I.	87.0		85.0
Oct. 17	Manila, P. I.	90.0		86.5
Oct. 18	Manila, P. I.	93.0		86.0
Oct. 19	Enroute to Cebu, P. I.	84.2	81.3	85.0
Oct. 20	342 miles south of Manila, at Cebu, P. I.	82.3	81.0	84.0
Oct. 21	Opon, P. I.	82.0		84.0
Oct. 22	Opon, P. I.	81.5	80.2	83.0
Oct. 23	298 miles south of Cebu, P. I.	80.6	80.0	83.0
Oct. 24	658 miles south of Cebu, P. I.	82.4	81.3	84.0
Oct. 25	976 miles south of Cebu, P. I.	83.2	80.8	85.0
Oct. 26	1,282 miles south of Cebu, P. I., at Surabaya, Java	83.4	81.0	85.5
Oct. 27	Surabaya, Java	84.0	81.5	
Oct. 28	Surabaya, Java	84.3	82.5	
Oct. 29	Semarang, Java, 165 miles west of Surabaya	83.8	81.7	87.0
Oct. 30	Batavia, Java, 230 miles west of Semarang	85.2	82.5	87.5
Oct. 31	Batavia, Java	90.0	83.4	88.5
Nov. 1	Enroute to Singapore	82.6	80.5	88.0
Nov. 2	276 miles north of Batavia	81.0	82.3	87.5
Nov. 3	500 miles north of Batavia, at Singapore, S.S.	83.0	81.0	88.0
Nov. 4	Singapore, S. S.	85.0	82.0	88.0

TEMPERATURES OF STORAGE COMPARTMENTS AND OF FRUIT

There are, of course, numerous factors which may influence the temperatures that may be maintained throughout the holds of refrigerated ships. Some of the apparently important ones may be listed as follows: (1) design and arrangement of refrigerated holds, (2) the stowage of the refrigerated cargo; (3) the character and temperature of the cargo when stowed; and (4) the variations in sea and air temperatures. These factors are discussed elsewhere in this report.

With increasing volume of commerce in fruits, economy demands the storing and transport of the largest bulk in the minimum space. In some ships, holds having a capacity of over 50,000 cubic feet are used for overseas transport of fruits. The experiments reported in this bulletin were conducted in lower holds having a capacity of about 15,800 cubic feet and in 'tween deck chambers of about 11,000 cubic feet.

Investigations by Kidd and West (1923) of the cargo temperatures of apples enroute from Australia to England emphasized the following conditions: (1) In the large holds of the ships perhaps none of the systems in use attained a uniform temperature throughout the cargo after loading. (2) There tended to be considerable lack of uniformity of temperature throughout the bulk of the cargo, especially in large holds. (3) Powerful fans and rapid air change are needed in the case of the battery system. (4) There is a general advantage in cooling as far as possible from the top, and vertical breaks in the cargo stack are desirable.

Workers in Great Britain conducted temperature measurements in a small hold with baffled side grids and no forced air circulation. The capacity of the hold was 6,430 cubic feet and it was only 7 feet 6 inches high. During the first few days, the typical range of temperatures about the sides and on the bottom was from 31° to 34° F; about the top the temperatures varied from 38° to 42° F. The difference from floor to ceiling varied during the voyage, but, except at the center, persisted to the extent of at least one degree increase per foot of height to the end of the voyage.

A similar study was made in a hold fitted with a battery substitute system, spoken of as the screened-grid and fan system. The air was passed from one side horizontally across the hold and out the other side by means of ports in air trunks. The results showed there was

a progressive rise in temperature across the hold, the fruit at one side being 14° F warmer than the other. On reversal of the air current, the temperature gradient was reversed and the fruit was subjected to an 8° F fluctuation every four to six hours.

Temperature measurements upon the Silverhazel were made primarily by means of electrical resistance thermometers. These thermometers were connected with the indicating instrument in the laboratory on the aft boat deck, by means of heavily insulated three-wire cables led out through the ventilators, which were plugged with wooden disks and sealed about the wires with waste, putty, and canvas. Mercury thermometers and recording thermometers placed within the holds were also employed.

Since the experimental cargo was stowed in the forward 'tween deck, the temperature conditions therein, as determined by the resistance and mercury thermometers, are summarized in table 2.

TABLE 2

The Average Air and Cargo Temperatures of the Forward 'Tween Deck of the Refrigerated Holds

Time interval	Air according to resistance thermometers	Air according to mercury thermometers	Center of cargo (resistance thermometers)
	°F	°F	°F
First 3 days	38.7	39.1	47.0
Throughout trip, 50 days	36.8	38.3	39.0

The temperature as determined by the mercury thermometers read by means of the thermometer wells, averaged 1.5° F higher than similar temperatures determined by resistance thermometers. This was interpreted as a slight error introduced by the fact that the ship's mercury thermometers had to be lifted up from the hold through the 'well' to the deck to be read, and this may have permitted slight warming. There was naturally a greater difference between the fruit cargo temperature and the air temperature during the first three days than was the case throughout the remainder of the voyage. Even after weeks of stowage in the refrigerated compartment, however, the fruit temperatures tended to be nearly 0.5° F higher than the surrounding air temperatures.

Temperature Variation Within the Conveying Duct.—The average temperature of the air carried through the ducts surrounding the forward 'tween deck of the Silverhazel are shown in table 3. The air

TABLE 3

THE TEMPERATURE DIFFERENCES IN THE AIR CHANNEL OF THE INLET AND OUTLET SIDES OF FORWARD 'TWEEN DECK COMPARTMENT

Date	Average air temperature in duct	
	Inlet side	Outlet side
	°F	°F
Sept. 14	40.2	42.5
Sept. 15	39.3	40.5
Sept. 16	36.0	37.5
Sept. 17	34.5	35.5
Sept. 18	35.2	35.7
Sept. 19	35.8	36.0
Sept. 20	36.0	36.0
Sept. 21	33.2	33.5
Sept. 22	35.8	37.0
Sept. 24	38.0	39.0
Sept. 25	36.5	37.8
Sept. 26	37.0	37.0
Sept. 27	34.6	39.5
Sept. 28	34.8	35.4
Sept. 29	35.0	36.0
Sept. 30	35.0	35.5
Oct. 1	35.0	35.2
Oct. 2	35.0	36.0
Oct. 3	35.1	36.0
Oct. 4	36.7	38.0
Oct. 5	36.2	37.8
Oct. 6	35.9	37.2
Oct. 7	36.1	37.4
Oct. 8	36.3	37.5
Oct. 9	35.8	37.1
Oct. 10	35.9	37.0
Oct. 11	35.0	36.0
Oct. 12	34.4	35.9
Oct. 13	37.0	38.0
Oct. 14	36.2	36.7
Oct. 15	36.5	36.9
Oct. 16	40.8	43.1
Oct. 17	39.4	42.3
Oct. 18	39.1	41.7
Oct. 19	38.8	39.0
Oct. 20	40.2	40.9
Oct. 21	39.1	39.7
Oct. 22	40.2	41.8
Oct. 23	38.5	38.9
Oct. 24	37.4	37.9
Oct. 25	37.0	37.7
Oct. 26	37.5	37.8
Oct. 27	37.3	37.8
Oct. 28	37.0	37.5
Oct. 29	36.3	37.1
Oct. 30	36.5	37.4
Oct. 31	34.8	36.0
Nov. 1	34.2	35.1
Nov. 2	34.0	34.9
Average	36.6	37.0

was introduced into the compartment through openings in the duct on the port side and removed from the hold and conveyed to the bunker of brine coils by means of openings in the duct on the starboard side. The temperature measurements given in table 3 are of the air (1) in the duct on the inlet side well forward on the port side near where the duct entered the hold, and (2) on the outlet side, well forward on the starboard side near where it left the forward 'tween deck.

The average temperature in the duct on the inlet side of the forward 'tween deck tended to be slightly lower than that in the duct on the outlet side. The volume of air in the duct and the rate of air flow, however, were such that this difference was not great, averaging only 0.4° F higher in the air of the outlet side.

Slightly greater differences in the air temperatures in between the stowed cargo were noted between the port (air inlet) and the starboard (air outlet) sides of the forward 'tween deck compartment. The greatest difference noted was during the first four days after the cargo was loaded when it averaged 6° F higher on the air-outlet side. During the succeeding interval of the trip the difference became less and throughout the last two weeks averaged about 2.5° F higher on the air-outlet side. The temperature determinations were taken about four feet from each side of the compartment and in air channels about midway between the top and the bottom of the cargo.

Average Fruit and Air Temperatures of Experimental Compartment.—The average daily air temperatures surrounding the experimental cargo, based upon readings of resistance and mercury thermometers in eight different positions in the compartment and of ten resistance thermometers placed in the centers of boxes of apples and pears, crates of plums, and grapes, and in kegs of grapes, are shown in table 4. These data are representative of the fruit and air temperatures of the other compartments, hence the additional data for the other three compartments are not presented.

It required somewhat over 48 hours for the air temperature to be lowered from that attained during the period of loading in San Francisco, 45.9° F, to the average that was maintained subsequently, 36.5° F. On the other hand, it required approximately seven days to reduce the average fruit temperature in the centers of the containers from its average initial temperature of 64.5° F, when the hatches were battened down, to the average that was maintained subsequently, 37.8° F.

There were slight fluctuations in the daily average temperatures of the air, and of course, of the fruit also, as a result of passing

through different outside air and sea temperatures, variations in the running of the compressor, and of the fans, and also as a result of opening the hatches for various reasons.

TABLE 4

THE AVERAGE DAILY TEMPERATURE OF THE EXPERIMENTAL FRUIT AND OF THE SURROUNDING AIR OF THE FORWARD 'TWEEN DECK

Date	Average air temperature	Average fruit temperature in center of packages
	°F	°F
Sept. 13	45.9	64.5
Sept. 14	42.3	59.7
Sept. 15	39.9	54.2
Sept. 16	37.1	46.2
Sept. 17	36.8	42.3
Sept. 18	35.0	39.8
Sept. 19	35.5	38.2
Sept. 20	35.8	37.7
Sept. 21	35.0	37.3
Sept. 22	34.7	37.0
Sept. 24	36.3	37.0
Sept. 25	36.9	37.1
Sept. 26	36.4	37.2
Sept. 27	34.7	36.9
Sept. 28	35.1	36.0
Sept. 29	34.4	35.7
Sept. 30	34.3	35.5
Oct. 1	34.7	35.7
Oct. 2	35.1	35.8
Oct. 4	37.4	37.4
Oct. 5	36.7	37.3
Oct. 6	36.7	36.9
Oct. 11	34.8	35.8
Oct. 12	35.4	37.0
Oct. 13	37.0	37.4
Oct. 14	35.9	37.3
Oct. 15	36.8	39.1
Oct. 16	39.6	40.0
Oct. 19	39.3	41.9
Oct. 20	41.0	41.9
Oct. 21	39.7	42.2
Oct. 22	40.9	41.6
Oct. 23	38.9	39.8
Oct. 24	37.7	38.1
Oct. 25	37.4	38.0
Oct. 26	37.8	38.1
Oct. 28	36.9	38.0
Oct. 29	36.6	37.7
Oct. 30	37.1	37.9
Oct. 31	35.1	37.3
Nov. 1	33.8	36.7
Nov. 2	34.8	36.6

Rapidity of Cooling of Fruit.—The rate of cooling of the contents of packed containers of fruit was influenced by several factors,

among which were: (*a*) kind of fruit; (*b*) type of package; (*c*) quantity of fruit stowed; (*d*) surrounding air temperature that could be maintained; and (*e*) rate of air movement in and about the containers.

It has been determined (Overholser and Moses, 1930) that grapes packed in lugs required 33 hours to be cooled from a temperature of 60° F to a temperature of 35° F, when placed in a warehouse room with an air temperature of about 32° F. The lug is a somewhat open container; the individual berries are not wrapped and are not placed tightly together. On the other hand, in a warehouse when pears were surrounded by air at similar temperatures it required from 45 to 50 hours to cool the centers of wrapped pears packed in the centers of standard boxes from a temperature of 60°–75° F, to a temperature of 33°–35° F. Oranges in the centers of each half of the divided orange box were cooled from 75° F to 35° F after about 64 hours storage in a warehouse temperature of 33° F. These differences in rapidity of cooling were also found to prevail in the ship's refrigerated holds. The rate of cooling on board ship, however, was somewhat slower than was true in warehouses on land.

The rate of temperature fall of non-precooled grapes and nectarines packed in sawdust in grape kegs was determined by means of electrical resistance thermometers. Sawdust makes an excellent insulator and the tight keg effectively prevents any appreciable air movement between the outside air and the contents of the package, so that cooling is markedly retarded.

TABLE 5

The Rate of Temperature Drop in Grape Kegs Packed with Humboldt Nectarines in Sawdust and Placed in Refrigerated Holds

(Initial temperature of fruit and containers 87.5° F.)

Time interval in hours	Average air temperature	Average fruit temperature at close of interval	
		In center of container	2 inches from sides
	°*F*	°*F*	°*F*
24	37.5	64.3	50.0
24	36.0	46.3	39.7
24	35.4	39.8	38.0
24	35.1	38.8	36.3
24	35.0	37.6	36.1
24	35.2	36.5	35.8

Because of different positions in the hold and different initial temperatures of the fruit, the data for nectarines and those for grapes are presented in separate tables.

The data for the Humboldt variety of nectarine are based upon the average of four containers, two kegs and two drums. No appreciable differences could be determined between the kegs and drums in rate of temperature drop. The data are shown in table 5.

When surrounded by air at a temperature of about 35° F in continuous circulation it required nearly six days, or 144 hours, to bring the temperature in the center of kegs of nectarines packed in sawdust from 87.5° to 36.5° F. It required about four days, or 96 hours, to bring the temperature down to about this point at a position approximately two inches from the side of the keg or drum.

Similar observations upon the rate of cooling are available for two non-precooled drums of White Malaga grapes packed with sawdust and stowed in the forward 'tween deck. The data are shown in table 6.

TABLE 6

THE RATE OF TEMPERATURE DROP IN GRAPE KEGS PACKED WITH WHITE MALAGA GRAPES IN SAWDUST AND STOWED IN REFRIGERATED HOLDS

(Initial fruit temperature 81° F.)

Date	Average air temperature	Average fruit temperature in center of keg
	°F	°F
Sept. 13	44.0	79.0
Sept. 14	41.2	74.0
Sept. 15	39.5	55.7
Sept. 16	38.0	45.5
Sept. 17	37.3	39.9
Sept. 18	36.1	38.8
Sept. 19	35.6	38.1
Sept. 20	35.5	37.6
Sept. 21	35.4	37.7

It required about seven days for grapes in the center of kegs packed with sawdust to reach refrigeration temperatures comparable with those of the surrounding air.

Hill and Hawkins (1925) studied the transportation of citrus fruit from Porto Rico. For one test, the average temperature of the fruit received for transportation was 80.4° F. In 12 hours after the fruit was loaded the temperature was approximately 74° F. At the end of the trip the average fruit temperature was 54° F, a reduction of 20° F in eight and one-half days, or about 2.35° F per day.

The slowness with which the temperature in the interior of such packages can be reduced even under most favorable conditions indicates the advisability of precooling not only the fruit, but also the sawdust and keg before it is packed.

Rapidity of Warming of Refrigerated Kegs.—The question is frequently raised as to how effective such a method of packing would be in maintaining low temperature after removal from storage. It would no doubt be of value in retarding the absorption of heat during the time the kegs or drums would be exposed to the tropical sun on the dock, when kept temporarily in the 'go-down' or warehouse, or when enroute by rail to inland cities in warm climates in cars which were not refrigerated.

After storage at a temperature of approximately 36° F, the four kegs and drums of nectarines packed in sawdust were removed to outside temperatures and the rate of warming observed. After three days the temperature in the center of one of the kegs showed a marked rise and the temperature thereafter remained considerably above air temperature. This was later found to result from the excessive growth of molds giving rise to heat of decay, which was retained by the insulation of the sawdust and of the keg. These temperatures are presented separately in table 7.

TABLE 7

THE RATE OF TEMPERATURE RISE IN GRAPE KEGS PACKED WITH HUMBOLDT NECTARINES IN SAWDUST WHEN REMOVED FROM REFRIGERATED HOLDS TO ROOM TEMPERATURES

(Initial average temperature 36.4° F.)

Time interval in hours	Average air temperature	Average fruit temperature at close of interval		
		In center of container		2 inches from sides
		Sound fruit	Decaying fruit	
	°F	°F	°F	°F
24	77.4	59.2	63.2	62.9
24	80.5	76.1	88.1	78.0
24	84.1	80.0	97.0	82.3

Within a period of about three days the average temperature at the centers of grape kegs containing nectarines packed in sawdust and removed from cold storage to room temperatures became essentially the same as that of the surrounding atmosphere. When the contents were decaying and badly molded the temperature after 48 hours became nearly 8° F warmer than that of the surrounding atmosphere; after 72 hours the temperature had become nearly 13° F warmer than that of the surrounding atmosphere. Twelve hours later, however, the temperature in the center of the keg had dropped from 97° to 94° F.

Effect of Open Hatches Upon Air and Fruit Temperatures.—The effect of opening the hatches of the refrigerated compartments, to take on or to discharge cargo, upon the temperatures of the air and fruit within the compartment is of interest. Such observations are shown in table 8.

TABLE 8

THE EFFECT OF OPENING HATCHES UPON TEMPERATURES OF THE AIR AND FRUIT WITHIN THE REFRIGERATED COMPARTMENTS

Date	Time hatches were open	Refrigerated compartment	Initial air temperature	Final air temperature	Average outside air temperature
			°F	°F	°F
Oct. 15	7:00 a.m.–2:35 p.m.	Forward 'tween deck	34.0	41.0	86.0
Oct. 15	8:10 a.m.–5:00 p.m.	Forward lower hold	36.0	40.0	86.0
Oct. 16	7:00 a.m.–5:00 p.m.	Forward 'tween deck	37.8	47.4	87.0
Oct. 28	9:15 a.m.–4:35 p.m.	Aft 'tween deck	34.0	45.0	84.3
Oct. 28	9:15 a.m.–4:35 p.m.	Aft lower hold	40 1	50.1	84.3
Oct. 31	11:00 a.m.–2:00 p.m.	Aft 'tween deck	35.5	49.0	90 0
Oct. 31	11:00 a.m.–2:00 p.m.	Aft lower hold	40.9	50 8	90.0

On the average the temperature in the refrigerated compartment came up about 1.5° F for each hour that the hatches leading to the particular compartment were open. When the hatches of any one compartment were first opened the rise in temperature was somewhat more rapid, and later the rapidity of rise was somewhat slower, than the average. Furthermore, the rise in the air temperatures of the lower holds was less marked than was the case in the 'tween decks. During the time the hatches were open, the 'tween decks served as buffers for the holds beneath.

In the tropics a large canvas tent is erected upon the deck of the Silverhazel over the hatch opening to keep the direct sun out of the open refrigerated holds (fig. 1.).

THE RELATIVE HUMIDITY

The term *humidity* is herewith employed to note the presence of water vapor in the atmosphere. The *relative humidity* is considered as being the actual pressure of the water vapor present divided by the maximum pressure that water vapor in the presence of water can exert at the same temperature. One hundred times this quantity is called the *percentage relative humidity*. The *dew-point* is that temperature at which the air would be saturated with the water vapor in it (100 per cent relative humidity). It is, therefore, the temperature

at which condensation of the water vapor to the liquid form should be observed.

If the relative humidity of the storage compartment is too low there is undue wilting and shriveling of the stored fruit because of loss of moisture by transpiration. There is little evidence that a humid atmosphere is in itself harmful to fruit. There is reason, however, to believe that the actual deposition of water from the atmosphere on the fruit, such as might result with too high a relative

Fig. 1.—Tent over open hatches of refrigerated holds of the Silverhazel and the 'aeroplane sling' lowering boxes of fruit in Surabaya, Java.

humidity and with temperature fluctuations, is objectionable and favors rotting through mold growth. Definite information is lacking as to the optimum relative humidity which should surround various varieties and species of fruits. In general, however, the relative humidity is maintained between 85 and 90 per cent, or as near this percentage range as is feasible.

The Relative Humidity and Barometric Pressure of the Atmosphere Enroute.—It is of interest, as well as of possible significance in its relation to the experiments, to present for the duration of the trip a day-by-day average record of the relative humidity of the atmosphere and of the barometric pressure. The relative humidity

was determined by means of recording hydrometers, which were frequently standardized by means of a sling psychrometer.

The barometric pressure was determined by means of two instruments, the barometer in the chart room of the navigation bridge, and a barometer in the experimental laboratory on the port aft boat deck. The barometric pressure given in table 9 is an average of these two readings. The lower the barometric pressure the higher the relative humidity at any given temperature, with the same depression of the wet-bulb thermometer. This error, however, is not significant with the barometric-pressure variations usually encountered.

The relative humidity of the atmosphere varied from 50 per cent, in the intense tropical heat of Surabaya, to 99 per cent in fogs and rain in the northwestern Pacific Ocean. The amount of saturated aqueous vapor that can exist in any given space depends upon the temperature. The higher the atmospheric temperatures the greater the amount. At high temperatures, such as prevail in the tropics, the actual water vapor present in the atmosphere would be greater at the same relative humidity reading than at lower temperatures, such as prevail in the temperate zone. As a rule, with a rise in temperature the relative humidity tends to become lower.

The Relative Humidity of the Storage Compartments.—The average daily relative humidity of the lower aft refrigerated compartment throughout the duration of the test trip is shown in table 10. This compartment is considered to be most representative of normal conditions, since it was least disturbed by opening of the hatches enroute to examine or to discharge the cargo. The hatches were not opened for any appreciable length of time from September 14 until October 28, when the cargo therein was discharged at Surabaya, Java.

From the time the cargo was stowed and the hatches closed until the latter were again open for discharge of the cargo, there was a slow gradual increase in the relative humidity from 69 per cent to 86 per cent. This probably resulted from the gradually increasing frosting of the brine pipes over which the air was conveyed for chilling, and from the constantly augmented amount of water vapor within the compartment as a result of that given off from the fruit.

Condensation of Moisture.—Dew will form or moisture will be precipitated from the air upon objects having temperatures sufficiently low to be below the dew point of the air reaching it. Naturally such condensation in the case of the surfaces of fruits and of containers would be objectionable. It is, therefore, of interest to note under what conditions such condensations might be expected to occur. The first possible case would be when precooled fruit was removed from

TABLE 9

THE RELATIVE HUMIDITY AND AVERAGE BAROMETRIC PRESSURE ENROUTE DURING THE EXPERIMENTAL TRIP

Date	Position	Relative humidity, daily range	Barometric pressure
		per cent	*inches*
Sept. 14	69 miles northwest of San Francisco	75 to 96	29.73
Sept. 15	424 miles northwest of San Francisco	72 to 87	30.01
Sept. 16	764 miles northwest of San Francisco	65 to 94	29.62
Sept. 17	1,074 miles northwest of San Francisco	66 to 87	29.71
Sept. 18	1,362 miles northwest of San Francisco	73 to 90	29.94
Sept. 19	1,690 miles northwest of San Francisco	72 to 91	29.82
Sept. 20	2,008 miles northwest of San Francisco	69 to 81	29.55
Sept. 21	2,342 miles northwest of San Francisco	69 to 91	29.27
Sept. 22	2,628 miles northwest of San Francisco	66 to 86	29.37
Sept. 24	2,868 miles northwest of San Francisco (180th meridian)	70 to 78	29.50
Sept. 25	3,088 miles northwest of San Francisco	70 to 80	29.72
Sept. 26	3,437 miles northwest of San Francisco	77 to 91	29.57
Sept. 27	3,772 miles northwest of San Francisco	75 to 96	29.56
Sept. 28	4,065 miles northwest of San Francisco	69 to 99	29.73
Sept. 29	4,393 miles northwest of San Francisco	81 to 88	29.55
Sept. 30	4,571 miles from San Francisco (Yokohama, Japan)	69 to 89	29.45
Oct. 1	38 miles south of Yokohama, Japan	62 to 86	29.86
Oct. 2	345 miles south of Yokohama, at Kobe, Japan	70 to 87	29.83
Oct. 3	Kobe, Japan	62 to 83	....
Oct. 4	Kobe, Japan	74 to 79	29 61
Oct. 5	239 miles south of Kobe, Japan	57 to 71	29 62
Oct. 6	594 miles southwest of Kobe, Japan	74 to 80	29 64
Oct. 7	772 miles southwest of Kobe, at Shanghai, China	59 to 74	29 65
Oct. 8	Shanghai, China	64 to 79	....
Oct. 9	Shanghai, China	70 to 81	....
Oct. 10	Shanghai, China	70 to 80	....
Oct. 11	25 miles from Shanghai, China	66 to 77	29 62
Oct. 12	373 miles south of Shanghai	61 to 78	29 62
Oct. 13	726 miles south of Shanghai	65 to 79	29 57
Oct. 14	1,058 miles south of Shanghai	67 to 82	29 50
Oct. 15	1,133 miles south of Shanghai, at Manila, P. I.	64 to 77	....
Oct. 16	Manila, P. I.	62 to 75	....
Oct. 17	Manila, P. I.	58 to 75	....
Oct. 18	Manila, P. I.	72 to 77	....
Oct. 19	Enroute to Cebu, P. I.	67 to 75	29 48
Oct. 20	342 miles south of Manila, at Cebu, P. I.	69 to 75	29 47
Oct. 21	Opon, P. I.	68 to 83	....
Oct. 22	Opon, P. I.	58 to 80	29 47
Oct. 23	298 miles south of Cebu, P. I.	74 to 83	29.51
Oct. 24	658 miles south of Cebu, P. I.	64 to 81	29 51
Oct. 25	976 miles south of Cebu, P. I.	69 to 76	29 53
Oct. 26	1,282 miles south of Cebu, P. I. at Surabaya, Java	61 to 75	29 54
Oct. 27	Surabaya, Java	50 to 73	29 52
Oct. 28	Surabaya, Java	50 to 77	29 50
Oct. 29	Semarang, Java, 165 miles west of Surabaya	56 to 78	29.50
Oct. 30	Batavia, Java, 230 miles west of Semarang	64 to 75	....
Oct. 31	Batavia, Java	61 to 75	....
Nov. 1	Enroute to Singapore	62 to 79	29 50
Nov. 2	276 miles north of Batavia	61 to 82	29 51
Nov. 3	500 miles north of Batavia, at Singapore, S. S.	74 to 89	29 50
Nov. 4	Singapore, S. S.	81 to 92	....

the precooling room on land to warm outside air on the dock awaiting the arrival of the ship. The second would be the stowage of precooled fruit into holds not previously brought down to temperatures approximating those of the precooled containers of fruit. The third would be the introduction of warm moisture-laden air into the refrigerated holds from the outside when the fruit and the containers had become chilled to the desired refrigeration temperature. The fourth would be the discharge of the fruit from the refrigerated compartment to the dock where it would be surrounded by warm air of a high relative humidity.

TABLE 10

The Average Daily Relative Humidity of the Atmosphete in the Aft Lower Compartment

Date	Relative humidity	Date	Relative humidity	Date	Relative humidity
	per cent		*per cent*		*per cent*
Sept. 13	69	Oct. 1	81	Oct. 19	84
Sept. 14	70	Oct. 2	81	Oct. 20	84
Sept. 15	71	Oct. 3	81	Oct. 21	84
Sept. 16	72	Oct. 4	81	Oct. 22	84
Sept. 17	73	Oct. 5	81	Oct. 23	85
Sept. 18	74	Oct. 6	81	Oct. 24	85
Sept. 19	75	Oct. 7	82	Oct. 25	85
Sept. 20	75	Oct. 8	82	Oct. 26	85
Sept. 21	75	Oct. 9	82	Oct. 27	86
Sept. 22	76	Oct. 10	82	Oct. 28	80*
Sept. 23	77	Oct. 11	82	Oct. 29	82
Sept. 24	77	Oct. 12	82	Oct. 30	80
Sept. 25	78	Oct. 13	83	Oct. 31	82
Sept. 26	78	Oct. 14	83	Nov. 1	84
Sept. 27	79	Oct. 15	83	Nov. 2	83
Sept. 28	79	Oct. 16	83	Nov. 3	80†
Sept. 29	80	Oct. 17	83		
Sept. 30	80	Oct. 18	84		

* Opened to discharge fruit, Surabaya. † Opened to discharge fruit, Singapore.

The second and third conditions can be avoided by proper refrigeration and handling of discharge of cargo. Condensation from these two conditions were not observed during the experimental trip.

When the refrigerated hold has been previously chilled and is loaded with warm fruit giving off water vapor through transpiration from the fruit and vegetable tissues, moisture may condense on the sides of the refrigerated compartment until the temperature of the fruit is lowered to more nearly that of the compartment. This moisture may run down the sides of the insulated walls into the bilges, but does not damage the cargo.

Furthermore, with the system of refrigeration employed on this ship, the air loses some of its moisture by condensation on the brine

coils, before it reaches the compartments in which the fruit is held. In fact, this may sometimes cause the air to become dry enough to wilt the stored fruits and vegetables. Such wilting can be lessened by not having the temperature in the brine coils too low. The nearer the brine-coil temperature can be to the air temperature desired in the refrigerated compartment the better. The brine temperature in the coils of the bunker room should preferably be not more than 2.5° to 3° F below the temperature to be maintained in the refrigerated compartments by the air conveyed into them, after passing over the coils, by air ducts.

COMPOSITION OF THE ATMOSPHERE IN HOLDS OF SHIPS

As stated, the fruits and vegetables in the ship's hold continue to respire, and remove oxygen from the air and give off carbon dioxide. Under the partially sealed conditions of a hold when well laden it is possible, especially if there is a delay in lowering the temperature of the commodities, and ventilation is inadequate, that the carbon dioxide content may become excessive and the oxygen supply deficient. Carbon dioxide, however, leaks in considerable amounts from the ship's holds carrying fruit overseas, the leakage being greater in rough than in calm weather at sea. The leakage is of importance in the successful transport of fruit, and lessens the possibility of the accumulation of injurious amounts of carbon dioxide. The evidence (Kidd, West, and Kidd, 1927), moreover, indicates that carbon dioxide concentrations of from 1 to 8 per cent may not be injurious to certain fruits, but instead may actually retard ripening.

Smith (1925) determined the leakage of carbon dioxide on two vessels with holds of the 'unventilated' grid type. Carbon dioxide was introduced into the empty holds and the amount of leakage was determined by analyzing the gas from day to day. The ships were in harbor during the experiment. The rate of leakage was considerable, but was less than had been postulated as occurring in fruit-carrying holds at sea.

The No. 2 hold of each vessel was charged with sufficient carbon dioxide to give a concentration of about 10 per cent after mixing. In vessel *A* the lower hold containing the gas had above it two insulated 'tween decks. All three holds had the insulated hatches and ventilator plugs in place, and were refrigerated during the test. As the gas was introduced into the hold through the thermometer tubes, it fell to the bottom of the hold and there formed a concentrated layer. Mixing by diffusion proceeded slowly, but when refrigeration was

commenced a rapid mixing resulted from convection currents. After 6 hours' refrigeration a uniform distribution of gas was reached and uniformity was maintained for the rest of the experiment.

With vessel *B* no refrigeration was applied to the hold, but the air was stirred by means of fans. The lower hold had above it one insulated 'tween deck and two uninsulated decks. The insulated hatches were placed on the lower hold and lower 'tween decks. The lower hatch was covered with sawdust and the crevices between the plugs were caulked with oakum. The lower hold ventilator plugs were placed in position.

The mean leakage values were 3,500 cubic feet of air per day in vessel *A*, and 1,350 cubic feet in vessel *B*. A leakage of 10,000 cubic feet per day had been assumed to be necessary for the safe carriage of fruit in the holds. The rate of leakage in port was increased to more than 10 times its original value merely by opening the thermometer tubes. It is suggested that a similar large increase in the rate of leakage is brought about at sea by the 'working' of the ship and perhaps also by changes of wind and barometric pressures over the hatch.

Leakage occurs mainly by the hatches, but to some extent also by the ventilator plugs. The gas passes freely by the bilge timbers into the bilge, but apparently does not escape further in this direction. No evidence was obtained of the passage of gas through the metal plates of the bulkheads or decks. The leakage apparently results partly from diffusion through the actual material of the hatch plugs and partly from the mass movement of air through the crevices between the plugs. The second is probably the more important. The increased leakage which occurs when the thermometer caps are removed, and the increased leakage postulated as occurring at sea, are thought to result from mass movement effect.

Further studies (Food Investigation Board, 1925) of the atmospheric conditions existing in ventilated and unventilated holds of ships carrying fruits from Australia to Great Britain showed no tendency for carbon dioxide to accumulate in low points. The composition of the atmosphere was approximately uniform throughout the hold and even within the boxes of fruit. Gas analyses in two unventilated holds showed an initial rapid rise in carbon dioxide to 10 per cent, followed by a fairly constant concentration, with a rise at the end of the voyage to a maximum of 12.8 per cent. The oxygen concentrations were inverse of the carbon dioxide so that the sum of carbon dioxide and oxygen percentages remained constant, or slightly over 21 per cent throughout the voyage.

Composition of Atmosphere Within the Compartments of the Silverhazel.—The air in the four refrigerated compartments of the Silverhazel was analyzed daily to determine the percentage of carbon dioxide and oxygen present. One-fourth inch copper tubing led from each hold up to the laboratory. Samples of air were obtained by attaching a vacuum pump to the copper tubing by means of heavy rubber tubing connections. When the air had been drawn through sufficiently long to give a constant representative sample the analyses were made. Two methods were employed, one was the use of the Cambridge carbon dioxide indicator for carbon dioxide alone, and the other was by means of a modified Orsat gas analysis equipment for

Fig. 2.—Waves and wind at the bow and abeam the ship in mid-Pacific ocean enroute to Japan. The vessel is pitching, rolling, pounding and shipping water from stem to stern.

both carbon dioxide and oxygen. Air samples were also obtained from time to time by entering the forward 'tween deck.

As long as the hatches were kept closed and no outside air was introduced for purposes of ventilation, the carbon-dioxide content in each of the holds tended to increase slowly and the oxygen content to decrease slowly. At no time during the experiment, however, did the change in the composition become sufficiently marked to be injurious to the stored commodities. With each determination the sum of the percentages of carbon dioxide and oxygen averaged slightly over 21. As the carbon dioxide increased the oxygen became correspondingly lower, and vice versa.

The appreciable effect of storms, wind, squalls, and rough seas (fig. 2), in tending to lower the carbon dioxide content and to raise the

oxygen content of the compartments to more nearly that of the outside air was a surprise. This effect probably resulted from the marked increased leakage of air into and out of the holds. On the other hand, the effect of the opening of the hatches in port and the partial discharge of the cargo was surprisingly low (table 11), although greater than that of storms at sea. The latter was just sufficient to prevent an increase, while the former lowered the percentage of carbon dioxide.

The first compartment to show a measurable accumulation of carbon dioxide was the aft 'tween deck. This was probably because it had no outlets at the bottom as did the lower holds, and also it was as completely filled with fruit as any of the compartments. The forward 'tween deck contained the experimental cargo only and was, therefore, only partially filled with fruit, and was entered more frequently for experimental observations than the other compartments.

On September 21, or about seven days after the hatches were battened down, the percentage of carbon dioxide in the air of the aft 'tween deck was 0.4, when the normal outside asmosphere had less than 0.03 per cent. On September 22, the percentage had increased to 0.5. From midnight of September 22 until 4 p.m., September 25, there were very rough seas with strong wind squalls, and during that time of nearly three days, there was no increase in the percentage of carbon dioxide. During the next 24 hours with only moderate sea and breeze the percentage of carbon dioxide increased to 0.6, and two days later on September 28, there was 1.2 per cent. A study of the data in table 11 indicates subsequent similar effects from heavy seas. These observations suggest that when the vessel is subjected to very heavy seas and strong winds, leakage is increased so that carbon dioxide accumulation in the refrigerated compartments is retarded appreciably. The data concerning the accumulation of carbon dioxide in the aft 'tween deck are shown in table 11. These data are representative and hence data for the other holds are not presented.

The percentage of carbon dioxide in the other refrigerated compartments varied in a manner similar to that shown for the aft 'tween deck compartment in table 11. The highest percentage of carbon dioxide was found in the aft lower hold. On October 28 just before the hatches were opened for unloading at Surabaya the amount of carbon dioxide, as determined by Orsat gas analysis, was 3.1 per cent.

Composition of Atmosphere Within Containers.—The percentage of carbon dioxide in the different containers tended to be about the same as the percentage in the surrounding atmosphere of the compart-

TABLE 11

THE PERCENTAGE OF CARBON DIOXIDE IN THE AFT 'TWEEN DECK AS INFLUENCED BY WEATHER AT SEA AND THE OPENING OF HATCHES TO DISCHARGE CARGO

(Cargo stowed and hatches battened down 1 a.m., Sept. 14.)

Date	Carbon dioxide	Weather at sea	Notes
	per cent		
Sept. 15	Trace	Moderate sea; slight breeze	
Sept. 16	Trace	Moderate swell; pitching easily	
Sept. 17	Trace	Moderate to rough sea; pitching	
Sept. 18	0.1	Moderate sea; light breeze	
Sept. 19	0.3	Moderate sea and breeze	
Sept. 20	0.3	Moderate to heavy sea; pitching	
Sept. 21	0.4	Rough beam sea; pitching, rolling	En route to Yokohama.
Sept. 22	0 5	Pitching, pounding, shipping spray	
Sept. 24	0.5	Violent squalls, shipping seas	
Sept. 25	0.5	Heavy swell; pitching and rolling	
Sept. 26	0.6	Rough following sea, rolling	
Sept. 27	0.8	Slight sea and breeze	
Sept. 28	1.2	Moderate swell; light breeze	
Sept. 29	1.4	Light breeze and swell	
Sept. 30	1.7	Heavy rain squalls	Anchored at Yokohama.
Oct. 1	1.7	Heavy following sea, rolling and pitching	En route to Kobe.
Oct. 2	1.7	Pitching, rolling, shipping sea	
Oct. 3	1.8	Raining	Anchored in Kobe.
Oct. 4	1.9	Light breeze, slight swell	
Oct. 5	2.0	Light breeze, slight swell	En route to Shanghai.
Oct. 6	2.3	Light breeze, slight swell	
Oct. 7	2.3	Strong breeze	
Oct. 8	2.4	Hatch open 1:10 p.m. to 4:00 p.m. loading eggs	Anchored at Shanghai.
Oct. 9	2.0		
Oct. 10	1.9		
Oct. 11	1.9	Heavy swell, pitching, strong breeze	
Oct. 12	1.8	Rough sea, pitching, rolling	
Oct. 13	1.9	Moderate sea, and breeze	En route to Manila.
Oct. 14	2.2	Smooth sea, light breeze	
Oct. 15	2.5		
Oct. 16	2.0	Unloading fruit, hatch open, 7:00 a.m. to 2:35 p.m.	
Oct. 17	1.8		Anchored in Manila.
Oct. 18	1.8		
Oct. 19	1.9	Fine weather, slight sea	En route to Cebu.
Oct. 20	1 9	Slight breeze, and sea	
Oct. 21	2.0		Anchored at Cebu.
Oct. 22	2.2		Anchored at Opon.
Oct. 23	2.3	Light breeze and sea	
Oct. 24	2.3	Calm and smooth sea	En route to Surabaya.
Oct. 25	2.4	Light breeze, slight sea	
Oct. 26	2.4	Light breeze, slight sea	
Oct. 27	2.5	Calm	Anchored in Surabaya.
Oct. 28	2.4	Unloading fruit, hatch open, 9:15 a.m. to 4:35 p.m.	
Oct. 29	1.0	Light breeze, smooth sea	Anchored in Semarang.
Oct. 30	0.9	Light breeze, smooth sea	Anchored in Batavia.
Oct. 31	0.8	Unloading fruit, 11:00 a.m. to 2:00 p.m.	
Nov. 1	0.8	Calm and smooth sea	En route to Singapore.
Nov. 2	0.9	Calm and smooth sea	
Nov. 3	1.0	Unloading fruit, 8:55 a.m. to 9:00 p.m.	Anchored in Singapore.
Nov. 4	0.5	Cargo unloaded	

ment. In the open Los Angeles and display lugs of grapes there were no measurable differences. This was also true of plums packed in four basket crates and of peaches and plums packed in peach boxes. However, there tended to be a slight increase in carbon dioxide in the centers of apple and pear boxes. Samples were withdrawn from the centers of such boxes by means of small copper tubes previously placed from the center of the package to the outside and fitted with a stopcock on the exposed end. Ten cubic centimeter samples were analyzed by means of an Haldane gas analysis apparatus. Representative data are shown in table 12.

TABLE 12

THE PERCENTAGE OF CARBON DIOXIDE AND OXYGEN IN AIR FROM THE CENTERS OF PACKED APPLE AND PEAR BOXES STORED IN FORWARD 'TWEEN DECK

Kind of fruit	Composition of surrounding air		Composition of air within box	
	Carbon dioxide	Oxygen	Carbon dioxide	Oxygen
Apples:				
Gravenstein	1.3	20.0	2.3	18.9
Yellow Newtown	1.3	20.0	1.9	19 4
Pears:				
Bartlett	1.3	20.0	3.5	17.7
Anjou	1.3	20.0	2.9	18.5

Plums and grapes packed in sawdust, either in kegs or drums, developed sufficient carbon dioxide to appreciably modify the composition of the atmosphere within the container. Three successive samples of air were removed from the centers of such containers by means of copper tubing inserted at the time the fruit was stowed in the ship's compartment. The average of the last two samples was used, the first one being somewhat low and apparently not representative of the atmosphere at the center. There were no measurable differences between the kegs and drums, the kegs being tightly fitted. The data are given in table 13.

The grape drum and keg apparently under certain conditions are sufficiently tight to permit an appreciable accumulation of carbon dioxide and reduction in oxygen of the enclosed atmosphere by the fruit packed therein.

To determine the possible greater modification of the enclosed atmosphere at higher temperature, a keg of Thompson Seedless grapes and a drum of Satsuma plums were removed from the forward 'tween deck where the temperature ranged from 35° to 38° F to the

laboratory where the temperature varied during the period of observation from 78° to 86° F.

The data concerning the composition of the atmosphere within the container after removal from the refrigerated compartment to the outside temperatures are given in table 14.

TABLE 13

The Percentage of Carbon Dioxide and Oxygen in Air from the Centers of Sawdust-Packed Kegs and Drums of Grapes and Plums Stowed in Forward 'Tween Deck

Kind of fruit	Composition of surrounding air		Composition of air within drum or keg	
	Carbon dioxide	Oxygen	Carbon dioxide	Oxygen
	per cent	*per cent*	*per cent*	*per cent*
Thompson Seedless grapes	1.2	20 00	3.6	19.6
White Malaga grapes	1.2	20.00	3.3	19.7
Satsuma plums	1.2	20.00	4.2	17.1

TABLE 14

The Percentage of Carbon Dioxide and Oxygen in Air from the Centers of Sawdust-Packed Kegs and Drums of Grapes and Plums Removed from Refrigerated Compartment to Air Temperatures

Kind of fruit	Days after removal	Composition of surrounding air		Temperature of fruit	Composition of air within drum or keg	
		Carbon dioxide	Oxygen		Carbon dioxide	Oxygen
		per cent	*per cent*	°F	*per cent*	*per cent*
Thompson Seedless grapes	3	0	21	73.8	5.1	16.7
Satsuma plums	4	0	21	74.1	6.5	14.7
Satsuma plums*	12	0	21	83.5	14.2	8.3

* Upon opening fruit found to be overripe, flesh darkened and some mold.

The data in table 14 indicate that after removal of drums and kegs from low temperature to higher temperatures it is possible for the carbon dioxide content to become sufficiently high and the oxygen content sufficiently low, when the containers are unopened for some time, to affect the ripening changes profoundly.

It is also possible that the accumulation of carbon dioxide in drums and kegs before storage or during storage may act deleteriously if the increase is excessive, but if the increase is moderate, may aid in retarding ripening of the fruit contained therein.

AIR CIRCULATION WITHIN THE COMPARTMENTS

Air movement within the refrigerated compartment is desirable because of the possible benefits as follows: (1) it facilitates rapidity of cooling; (2) it lessens possible wide variations in temperature in different positions within the same compartment; (3) it makes possible better control and greater uniformity of humidity; (4) it reduces opportunity for accumulation of carbon dioxide and possible deleterious volatile products from stored fruit; and (5) it lessens oxygen deficiency within the compartment.

Among the factors affecting air movement, and consequently temperature, the two probably most important are: (1) design and arrangement of refrigerated holds; and (2) stowage of the cargo. These factors are briefly discussed later.

The difficulty in cooling the middle of a load of fruit and vegetables in a hold is recognized. There is inadequate free passage for the air to travel through the load. The fruits in the middle layers and in the center of the load, therefore, are not so readily refrigerated as in the top and bottom layers, because of the difficulty of obtaining sufficient air movement even with forced air circulation.

The importance of some of the features discussed in the paragraphs pertaining to stowage of the cargo (p. 28) can be emphasized by the measurements of air movement within the holds as determined by air meters. Measurements were made of the rate of air flow from the open portholes of the air ducts on the port or air-inlet side and on the air ducts of the starboard or air-outlet side of the forward 'tween deck. The ducts were the height of the room and about 12 inches wide. Portholes at different positions fore and aft and top and bottom permitted the air to be forced into the room on one side and drawn out on the opposite side. Data showing the decline in rate of air flow with greater distance from the fan are shown in table 15.

TABLE 15

THE RATE OF AIR FLOW FROM OPEN PORT HOLES OF INLET DUCT OF FORWARD 'TWEEN DECK

Position of port hole in air duct	Rate of air flow in feet per minute
Upper forward starboard (nearest force fan)	1,174
Upper aft starboard	840
Upper aft port	445
Upper forward port (furtherest from force fan)	284

Furthermore, the rapidity of air flow dropped markedly with increased distance from the duct port holes discharging air into the compartment. For example, from an upper air port hole as determined one foot from the opening, air was moving in above the cargo at the rate of 245 feet per minute; at a distance of 15 feet the rate of air movement was barely perceptible. In the cargo below, the rate of air movement fell off much more rapidly and quickly became imperceptible with the air meter. It was perceptible only by the drift of tobacco smoke blown down in the cargo.

Design and Arrangement of Refrigerated Holds.—Balfour (1924) has pointed out that some of the original difficulties met with in the details of construction of refrigerated holds result from obstruction, such as in the wide side stringers of the beams and propeller shafts tunnel. It is desirable to approximate the conditions obtained in land cold storages as far as possible, by eliminating projections from the sides, ceiling, or floor of the holds. Such projections and obstructions not only tend to create a defective air circulation, but also afford additional surface for the transmission of heat from the outside into the interior of the cargo space.

In recent years there has been a tendency for increased subdivision of insulated spaces, rendering them suitable for expedient loading and unloading of cargo. This has been especially beneficial in the carriage of fruit and vegetables and has provided facilities for isolating a particular kind of cargo requiring a different temperature from that in another chamber. Furthermore, insulated trunked hatchways fitted with doors have been introduced, which form air locks at the various 'tween decks and permit any compartment to be worked independently of the other.

The two principal methods of marine refrigeration are, (1) the cold-brine system, and (2) the cold-air battery system. While the former is successful for meats, the latter is preferable for fresh fruits and vegetables.

With the brine-pipe cooling system, the pipes are hung in coils on the ceiling or sides and the chilled brine is pumped through them. Such ships generally have no forced circulation to equalize temperatures throughout large cargo spaces. The drip from the moisture or melting frost accumulating on the pipes may fall on the cargo and temporary expedients cannot be relied upon to prevent the drip from wetting the cargo. The brine temperatures, especially when used to refrigerate meats in other holds, tend to be so low that there is danger from freezing injury, particularly near the coils. In an effort to

prevent possible freezing injury, there may be the tendency to bring the temperature down too slowly or to carry the temperature too high. Hence ripening and the accumulation of carbon dioxide may proceed too rapidly and spoilage may result.

With the cold-air battery system sufficient independent air coolers and ducts should be installed to permit separate air circulation being run into each refrigerated chamber to lessen the possible contamination of one product by odors of another. Some ships have both systems installed.

Griffiths and Davies (1926) make suggestions concerning air circulation as follows: (1) circulation of air is a necessity with 'tween deck or lower hold to obtain uniform temperature conditions. This circulation also has advantages in controlling gas and moisture conditions for fruits. (2) The sound and reliable system for air circulation is the self-contained battery with sectioning valves. The battery chamber should also be subdivided into two compartments for convenience in thawing frost deposits. Thawing facilities are essential for fruit ships. (3) The batteries of refrigerating coils and fans should be in, or near, the chambers or holds, and not trunked for long distances. A number of small units are preferable to one or two large ones. (4) The air circulation must be adequate, and approximately 15 to 20 cubic feet of air per minute per shipping ton of fruit should be provided. The fans recommended are centrifugal multivane type, to develop ample flow through closely stowed fruit boxes. (5) The air trunks should be distributed to make a short path for the air through the fruit from delivery to suction. This avoids excessive gradient of temperature from heating of the air in a long passage through warm fruits.

Stowage of the Cargo.—When possible, the loading of any particular chamber should be performed in one operation until the chamber is fully stowed. The frequent opening and closing of the chamber and the introduction of cargo at different times may tend to favor precipitation of moisture upon the cargo, and this 'sweating' may result in damage. In loading the refrigerated holds of vessels, the fruit should be stored rapidly and in such a manner as to: (1) get as much fruit as possible in the space; (2) permit circulation of air around the fruit to cool it quickly to the desired temperature; (3) permit the ventilation necessary to remove gases given off by the fruit and to introduce oxygen; (4) arrange the containers firmly so that they will not be dislodged and thrown about by the motion of the ship in heavy seas; (5) allow ready discharge at the port of desti-

nation. Cooling air should be delivered over the top of the fruit, and suction should be accomplished by a wide trunk around the sides of the hold.

Before loading a refrigerated cargo, the heat should be removed from the air in the holds, from the insulation, and preferably from the cargo itself, by precooling. The greater the difference in temperature between the hot and cold sides of the insulation, the greater will be the amount of heat that will flow through the insulation. It is necessary under certain methods of construction, therefore, to provide means of allowing the heat to be carried off. This may be done by forming vertical air channels on the sides and bulkheads by cargo battens or at least 2 by 2 inch timber, securely fastened.

All air channels should be kept free, and no refrigerated produce should be stowed in direct contact with the insulation, since if the air channels are not maintained, the heat or cold, as the case may be, passing through the insulation would be more likely to be transmitted to the produce, and possible damage result.

Dunnage, or strips of board, at least 1 inch and preferably 2 inches thick, placed between the layers of boxes as they are stacked in the holds, should be used to provide for air circulation and to tie the load securely in place and lessen possible damage when the vessel is laboring in a heavy seaway. It appears advisable to place dunnage battens between each tier. The provision of vertical air channels is also desirable. For example, about every fifth tier, counting fore and aft, a vertical air channel about 3 inches wide may be formed with proper dunnage battens.

Furthermore, at every fifth layer of boxes a double layer of battens should be laid with the bottom layer placed fore and aft to create horizontal airways at right angles to each other. The boxes must be stowed well clear of overhead, side, and bulkhead grids. Suitable dunnage should be used to allow free air circulation; other methods, such as wider stacking, cut down on the carrying capacity of the vessel and increase the possibility of broken boxes resulting from shifting of the cargo.

When possible, the cargo should be stowed at the same height throughout the hold, rather than close to the ceiling at one end or side and only halfway to the ceiling throughout the remainder of the hold. If the latter method of stowage is practiced, the air tends to be shunted around the high stacks and through the low stacks where the resistance is less. As a result, the center of the high stack, which needs more air, receives less. This is especially true if the air enters from the bottom of the hold.

In the stowage of a mixed refrigeration cargo the following points are considered: (1) stability and trim of the vessel, (2) rotation of loading and discharge ports, (3) nature of produce, (4) temperature of cargo to be maintained, and (5) ventilation required. In the stowage of the fruit cargo with respect to possible temperature differences existing in the same compartment, grapes, especially those packed in sawdust in kegs, or chests, can be with greatest safety placed in the cooler positions, where the temperature may vary from 30° to 32° F. On the other hand, oranges, lemons, grapefruit, avocados, and potatoes should be stowed in the positions where the temperature may vary from 38° to 40° F, somewhat higher than the average in the compartment; otherwise physiological difficulties may develop. Other commodities can be placed where the temperature may vary from 32° to 34° F. Such differences are likely to exist in different positions of stowage in many marine refrigerated compartments and to be recognized by the ship's engineer.

Where there are marked differences in the rate of air movement, kegs and chests of grapes might withstand an excessive movement of air that would result in wilting of such commodities as celery, cauliflower, and lettuce (unless the latter was packed in veneer boxes with fine sawdust, in which case the excessive air movement may be beneficial). Apples and pears are benefited by a moderate air movement in contrast with stagnant air, because air circulation opposes the development of scald. Excessively rapid air movement, however, may result in undue loss of water with consequent wilting and shriveling.

Unless the holds are provided with slatted false floors, 3 by 3 inch dunnage battens should be laid on the floor athwartship, and spaced according to the dimensions of the boxes or crates. The containers should be stowed in a fore and aft direction and the dunnage so spaced that the ends of adjacent boxes can be butted on each batten. Boxes that have a center partition and are comparatively long, such as those used for oranges, should be stowed with intermediate battens arranged to afford support to the center partition. Much depends upon laying the first tier of boxes advantageously. As far as practicable, the upper tier should be stowed directly over the lower tiers.

HANDLING FRUIT IN LOADING AND UNLOADING

There should be no need to emphasize the necessity of careful handling of fruit boxes. It is evident that if the thin tops and bottoms of fruit boxes are subjected to pressure or rough handling, breakage of the container or bruising and crushing of the fruit or shattering from the stems will result. Even with strong containers, careless handling after a long carriage will invariably damage the contents of fruit and vegetable boxes. Yet the writer frequently observed at

Fig. 3.—Aeroplane sling used in discharging boxes of fruit from the ship to the pier. (Photo by Carl Spurlock.)

each of the ports visited in the Orient unpardonably rough handling of fruit by men whose interest and experience should have led them to exercise precaution.

During the loading and unloading, careful attention must be given to the manner in which fruits and vegetables are gotten on and off the ship. For fruit in boxes or crates, tray, rather than rope or wire, slings should be used for lifting the cargo in and out of the hatches. The 'aeroplane' sling has come into use (figs. 1 and 3), and appears to be a good type, holding boxes securely and yet not chafing or breaking them, or injuring the fruit with the ropes. The aeroplane sling consists of a rectangular platform fitted with ropes, passing from each corner through rings in the ends of spreaders to the hook on the tackle cable. The spreaders are comparable to 6-inch angle

iron, the length of a box of fruit, placed over the side edges of the top box at each end to prevent the ropes from cutting into the boxes and to take the lateral strain. Nets extend from the spreaders to the

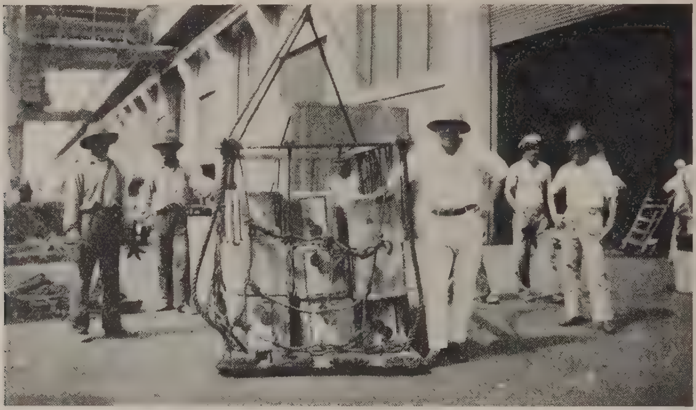

Fig. 4.—Sling used to discharge fruit boxes and egg baskets from the ship in Manila at Pier 7. (Photo by Carl Spurlock.)

Fig. 5.—A rope sling load of kegs of grapes being discharged from the ship to the dock in Batavia, Java. (Photo by Carl Spurlock.)

floor of the platform at the two ends and ropes across the two sides. In Manila a very good modification in the form of a tray is used (fig. 4).

It is possible that slings (fig. 5) can be used for grapes in kegs packed with sawdust, but the kegs should certainly not be dumped or rolled out by lifting one side of the sling with the hoisting cable and pulling it from under. The sling should be disconnected if necessary and each keg lifted out and carefully placed on the dock before the sling is again hoisted to be returned to the hold.

Boards or skids should be placed in the square of the hatch upon which to land the goods; walking-boards for the men should be used to lessen possible damage to the cargo underneath.

The use of mechanical conveyors to carry the cargo on board and from the hatch to the part of the chamber where stowage is under way would lessen the possible breakage of containers. Boxes and crates should be of standard dimensions to permit best stowage.

RESPONSE OF FRUIT TO TEMPERATURE

There are numerous false opinions held concerning the placing of agricultural produce at low temperatures. One of these fallacies of opinion is that cold-stored products are necessarily inferior to products not cold-stored. The application of the low temperature is not of necessity detrimental unless the temperature is low enough to injure the produce by freezing. With some products freezing temperatures can be employed to lengthen the period of time they can be retained for utilization in certain ways. Many fruits and vegetables are being frozen in increasing quantities for use either frozen, cooked, or in some other manner as fresh fruits would be used.

If the product is in poor condition at the time it is stored, it will not be in better condition when withdrawn. If, however, it is in good condition at the time it is stored, it should remain in first-class condition throughout its normal storage life, provided the refrigeration has been properly applied.

Certain metabolic activities of fruits and vegetables continue even after the products are harvested. The fresh produce respires, or takes in oxygen from the air and gives off carbon dioxide and a small amount of water vapor. As a result of these metabolic activities alone, the plant tissues gradually become overripe and sometimes shrivel, and physiological and morphological organization breaks down. The growth of rot organisms generally accompanies or quickly follows the attainment of overripeness and decay results.

The placing of fresh fruits and vegetables at low temperatures that do not freeze the tissues prolongs the period of time the com-

modities remain marketable. For each 15° F drop in the temperature of the fruit, the rate of ripening and rapidity of growth of rot organisms is reduced approximately one-half. There are, of course, other factors involved in the keeping quality of fruits and vegetables as discussed elsewhere in this bulletin.

There is much misunderstanding among fruit handlers and refrigeration engineers concerning the proper storage temperatures for fruits and vegetables. In the judgment of the writer, some of the cold-storage rooms in the ports of the Far East have been kept at temperatures unnecessarily high, from 38° to 42° F. The statement was

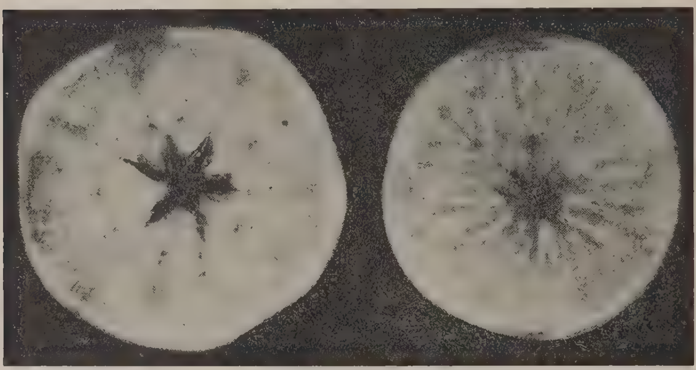

Fig. 6.—Two stages of internal browning in a Yellow Newtown apple.

frequently made in the ports by men interested in agricultural produce, that fruits would freeze at 32° F. Distilled water, of course, freezes at this temperature, but fruits, with substances such as sugar and acids in solution in the juices and with the colloidal structure of the tissues, do not freeze at 32° F. The freezing point of most fruits is several degrees below this point; for example, the freezing point of apples seems to be about 28.5° F (Wright and Taylor, 1923; Carrick, 1924).

It is true that certain tropical fruits, such as the banana and avocado, may show a disturbed metabolism resulting in discoloration or improper ripening at temperatures below 45° F. With most deciduous fruits, when it is desired to prolong their period of marketability with minimum loss, temperatures of 32° to 34° F are more effective than are higher temperatures.

It should, however, be pointed out that generalizations concerning the optimum storage temperatures for fruits of even a single species

may be unsafe. It is believed (Kidd and West, 1925; Overholser, 1927) that by storage at temperatures of 30° to 32° F the course, character, or balance, of the ripening changes in fruits and vegetables may be affected, as well as the rate of ripening. This disturbance of the balance may bring about deleterious effects which make it difficult to determine a single optimum storage temperature for the greatest retardation of the metabolic processes of fruits. Much depends upon the particular variety, the previous environment, the stage of ripeness attained when harvested and stored, the duration of the particular storage temperature, the amount of aeration, and other factors. Internal browning (fig. 6) and soft scald develop earlier in the season and with greater severity when apples are stored at 32° F than when stored at somewhat higher temperatures. The development of scald and bitter pit is opposed by rapidly cooling and maintaining the fruit at a temperature of 32° F or slightly lower.

EFFECT OF COMPOSITION OF THE ATMOSPHERE ON FRUIT

Data reported in this bulletin (pp. 21–25) and by Kidd and West (1923) and other workers indicate that the refrigerated holds of ships may under some conditions become semi-sealed compartments.

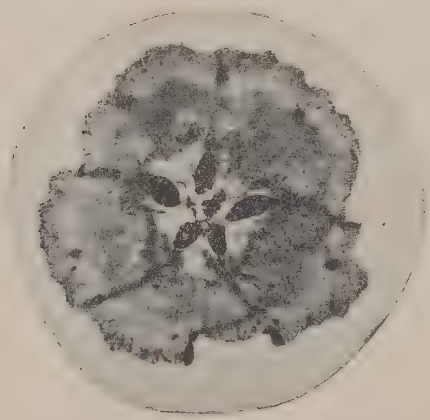

Fig. 7.—Cross-section of an apple showing brown heart. (After Kidd and West, 1923.)

Hence, the fruits and vegetables stored therein may appreciably modify the composition of the enclosed atmosphere. When the composition of the atmosphere is modified so that the carbon dioxide is not over 10 per cent and the oxygen not below 10 per cent and the

surrounding temperature 40° to 45° F, the rate of ripening may be retarded with little likelihood of serious physiological disturbances of the fruits (Kidd and West, 1930).

On the other hand, at temperatures of 32° to 35° F or those recommended for the carrying of most fruits and vegetables, reduced oxygen concentrations and increased carbon dioxide concentrations accelerate breakdown or brown heart. This latter trouble is characterized (Kidd and West, 1923) as a disease resulting from a percentage of carbon dioxide above 10 per cent and a percentage of oxygen below 10 per cent at cold storage temperatures of 32° to 35° F. The disease (fig. 7) results in browning and death of parts of the internal fleshy tissue, while the peripheral flesh generally remains sound.

KEEPING QUALITIES OF VARIETIES IN THE EXPERIMENTAL CARGO

The experimental cargo included varieties of plums, peaches, grapes, pears, apples, oranges, lemons, grapefruit, avocados, lettuce, celery, and melons. The responses of these perishables to various conditions of growth, preparation, and stowage aboard ship were studied. The relative keeping qualities of different species of deciduous fruits at room (65° to 75° F) and at cold-storage (32 F) temperatures, is indicated in a general way in table 16 (Overholser, 1927).

TABLE 16

THE RELATIVE EFFECTIVENESS OF 32° F AND 65° TO 75° F IN DELAYING SENESCENCE OF SEVERAL KINDS OF FRUIT

Kind of fruit	Number of varieties stored	Number of years observed	Temperature of storage	Optimum storage period	Maximum storage period
			°F	*days*	*days*
Apples	25	3	32	165	197
Apples	25	3	65–75	16	25
Pears	52	6	32	106	147
Pears	52	6	65–75	12	16
Plums	21	3	32	47	65
Plums	21	3	65–75	7	9
Peaches	49	2	32	37	50
Peaches	49	2	65–75	6	8
Apricots	29	3	32	23	32
Apricots	29	3	65–75	5	6

These data were obtained with fruits under optimum conditions with minimum handling. They are not the average response under commercial conditions, of even the better-keeping varieties of each

species. They show, however, the average difference in keeping qualities of the five species and that the effectiveness in retarding senescence, of cold-storage temperature (32° F) as contrasted with temperatures of 65° to 75° F, varied with the inherent keeping qualities of the species. The greater the inherent keeping quality of the fruit (at room temperatures), the greater proportionally was senescence delayed by cold storage.

Pears.—The average keeping quality of properly harvested and packed pears carried under good marine refrigeration is shown in table 17. The keeping period given is that which resulted when the fruit was moved quickly into cold storage after packing and not retained a week to two weeks awaiting the arrival of the ship. The term "optimum retention period" refers to the total time the fruit can be held between picking and consumption without appreciable losses; this time includes not only that spent in transit but also any periods of storage before and after transit and the time required for marketing after removal from storage. The "maximum retention period" refers to the longest period it could be similarly kept before such excessive losses might be expected to occur as to make marketing of it unprofitable.

TABLE 17

THE AVERAGE KEEPING PERIOD OF VARIETIES OF PEARS UNDER MARINE REFRIGERATION (35° TO 40° F)

Variety	Optimum retention period	Period marketable	Maximum retention period	Period marketable	General cause of failure
	days	*days*	*days*	*days*	
Forelle	140	8	175	6	Wilt, *Penicillium*.
Winter Nelis	130	8	165	5	Wilt, *Penicillium*.
De Anjou	110	7	155	5	Wilt, scald, and internal breakdown.
Glout Morceau	110	7	150	5	Wilt, scald.
Easter	100	7	145	4	Penicillium, wilt.
Bosc	90	6	130	4	Wilt, scald, and *Penicillium*.
Comice	80	5	120	3	Scald, internal breakdown, bruises.
Hardy	60	5	100	3	Wilt and scald.
Angouleme	55	5	90	3	Scald, *Penicillium*.
Howell	50	4	80	3	Scald and internal breakdown.
Clairgeau	40	4	70	3	Scald, wilt.
Bartlett	21	3	35	2	Scald and internal breakdown.

The *Bartlett* pear will keep satisfactorily as far as Shanghai or farther when properly grown in regions producing fruit of good keeping quality, picked at a desirable stage of maturity, and stored at the recommended refrigeration temperature enroute. Some deterioration and loss can frequently be expected by the time the cargo reaches Manila. The Bartlett does not carry as well as is desired. The fruit

tends to scald and to become soft at the core by the time the pears reach Manila. Furthermore, the fruit upon reaching Manila is generally soft and yellow, while the Chinese dealers desire firm-textured, green-colored fruit. If the ocean voyage calls for a period of retention longer than four weeks there are almost certain to be objectionable losses; and if the duration of the trip is six weeks or longer, the result can be expected to be disasterous.

The *Clairgeau* and *Howell* not only lack keeping quality, but also are inferior in eating quality and hence are not recommended for export purposes. While the *Angouleme* keeps better it is still of only mediocre eating quality. Nevertheless, because it retains its green color it may meet with some demand in Oriental markets. The *Comice,* while a delicious fruit which keeps satisfactorily, is not so well adapted for export because its large size and irregular shape subject it to excessive bruising.

The three best export varieties on the basis of keeping quality, flavor, and attractive appearance are the *Bosc*, *Anjou,* and *Forelle.* The *Easter* keeps well, and has the green color apparently desired by the Chinese fruit dealers of the Far East, but is not so high in quality as the other three just mentioned and seems to be especially susceptible to attacks of the blue mold (*Penicillium*). The *Hardy* should be a successful export pear having good keeping and eating quality. The *Glout Morceau* keeps well and retains its green color, but is low in eating quality and acid in flavor.

Apples.—The average maximum keeping quality of properly harvested and packed apples, stored previous to shipment and also during shipment under marine refrigeration, and disposed of with minimum delay after discharge in the foreign ports or possibly temporarily placed in cold storage after discharge, is shown in table 18. The average approximate harvest period on the Pacific Coast is also indicated. Both of these approximate dates will vary somewhat from year to year and are influenced also by the section in which the fruit is grown.

It may be indicated that for the Chinese trade and for the Chinese fruit dealers the *Yellow Newtown, White Winter Pearmain,* and *Ortley* meet with widest approval. For the so-called European trade the *Arkansas Black*, *Winesap*, *Rome Beauty*, *Delicious*, *Esopus* (Spitzenburg), and *Stayman Winesap* are most satisfactory. The *Yellow Bellflower* is not desirable because it is low in quality, irregular in shape, shows bruises badly and does not keep well. The *Gravenstein* is accepted by some importers because it may be used to supply the trade with apples during the first shipments received. The earlier

TABLE 18

The Average Latest Dates for Cold Stored Apples to Reach Oriental Markets Without Excessive Scald, Overripeness and Other Deterioration

Variety	Approximate harvest dates on Pacific Coast	Maximum arrival dates
Arkansas Black	Oct. 25 to Nov. 15	April 15 to May 1.
Winesap	Oct. 25 to Nov. 10	April 1 to April 15.
Yellow Newtown	Sept. 25 to Oct. 10	March 15 to April 1.
Rome Beauty	Sept. 25 to Oct. 15	March 15 to April 1.
Delicious	Sept. 1 to Sept. 20	March 1 to March 15.
Winter Banana	Sept. 1 to Sept. 15	Feb. 15 to March 1.
White Winter Pearmain	Sept. 10 to Sept. 30	Feb. 15 to March 1.
Esopus	Sept. 20 to Oct. 10	Feb. 1 to Feb. 15.
Stayman Winesap	Sept. 15 to Sept. 30	Jan. 15 to Feb. 1.
Ortley	Sept. 15 to Oct. 1	Jan. 1 to Jan. 15.
Jonathan	Aug. 25 to Sept. 25	Dec. 15 to Jan. 1.
Yellow Bellflower	Sept. 1 to Sept. 15	Nov. 15 to Dec. 1.
Gravenstein	July 10 to Aug. 15	Oct. 15 to Nov. 1

picked fruits, however, tend to shrivel and show bitter pit, and the later picked fruits rapidly become yellow in color, mealy in texture, and overripe.

Plums.—Varieties of plums have not been uniformly carried with success to the ports of the Far East under marine refrigeration. They tend to deteriorate rapidly after they are discharged in the ports having a tropical climate, and must be quickly disposed of and consumed. Some of the varieties shipped in the past have not been those that rank highest in quality and have been small in size. As a result, the trade has been reluctant to assume the risk of losses likely to occur in handling plums.

TABLE 19

The Approximate Ripening Date and Arrival Period in Foreign Ports Under Marine Refrigeration of Export Plums

Variety	Average time of ripening	Optimum marine-refrigeration period*	Approximate period for consumption after discharge	Maximum marine-refrigeration period*	Approximate period for consumption after discharge
		days	*days*	*days*	*days*
Golden Drop	Aug. 20–Sept. 10	30–35	4 or 5	45–50	3 or 4
President	Aug. 15–Sept. 5	28–32	4–5	45–50	3–4
Burton Prune	Aug. 15–Sept. 5	30–34	3–4	45–50	3–4
Grand Duke	Aug. 1–Aug. 25	28–32	3–4	40–45	2–3
Yellow Egg	July 30–Aug. 15	25–30	3–4	35–40	2–3
Sugar	July 20–Aug. 10	28–32	3–4	30–35	2–3
Imperial	July 15–Aug. 10	28–32	3–4	30–35	2–3
Kelsey	July 20–Aug. 10	30–35	3–4	45–50	2–3
Wickson	July 10–July 25	28–32	3–4	40–45	2–3

* See page 36 for interpretation of "optimum" and "maximum" refrigeration periods.

Nevertheless, the larger sizes and better-keeping sorts, picked at the proper stage of maturity, specially packed (see p. 54), and placed on boats departing soon after harvest, may be expected to reach such ports as Shanghai, Hongkong, Manila, and others not over four weeks away.

The approximate time of ripening and the average period of keeping under marine refrigeration of some of the better varieties are shown in table 19.

The *Golden Drop,* also known as the Silver Prune, is late in ripening; the color of skin and flesh is golden yellow; and the flavor is very good. The *President* is a large, attractive, firm, yellow-flesh plum with the skin having a deep purple color and whitish bloom. The *Burton Prune* is large in size with reddish-blue skin color, and with flesh of high eating quality. The *Grand Duke* is of good size, with dark reddish-purple colored skin and flesh of fair quality to eat. The *Yellow Egg* plum is of good size and excellent quality; the skin is yellow in color. The *Imperial* is of good size, with reddish-purple skin, and flesh of the best sweet eating quality. The preceding plums are varieties of the European species of *Prunus domestica,* which in shape is generally elongate, oval, and somewhat compressed on one side.

The *Kelsey* is a large conical plum, with greenish-yellow color, sometimes with a bronze-reddish tinge. The flavor is fair, being slightly acid. The *Wickson* somewhat resembles the Kelsey in shape, but is smaller in size. The color of skin is red, and the flavor is sprightly. These last two varieties are derived from the Japanese species, *Prunus salicina.*

Grapes.—The average harvest dates and approximate keeping periods under marine refrigeration when packed in kegs or drums with sawdust, of the more important shipping grapes of California are shown in table 20.

TABLE 20

THE HARVEST PERIOD AND REFRIGERATION PERIOD OF CALIFORNIA SHIPPING GRAPES

Variety	Approximate harvest period	Approximate refrigeration retention period
		days
Sultanina	July and August	40
Malaga	Middle of July and August	50
Olivette Blanche	August and September	40
Cornichon	September and October	65
Flame Tokay	September and October	55
Ribier	September to October	45
Alexandria	September and October	40
Emperor	October through November	75

While there were no grapes of the *Ohanez* (Almeria) variety in the experimental shipment, it has been long recognized upon the basis of limited quantities grown in California and large quantities grown in other countries, that it is one of the best keeping sorts for export purposes.

The *Sultanina* is commonly called the Thompson Seedless. It is planted to some extent in the Imperial and Coachella valleys and there it will ripen as early as June 25. The variety has seedless, yellow-colored berries, high in quality. The bunches may be large, but the individual berries are small. The pedicels are fragile, and when held long in a warm dry atmosphere they dry and the berries shatter easily.

The *Malaga* produces large bunches of large yellowish-white berries of very good quality. The *Olivette Blanche*, sometimes called Lady Finger, has large, elongated, curved oval, whitish berries. The berries, however, tend to shatter somewhat badly. The *Cornichon* is similar in shape to the Olivette Blanche, but the color is a deep bluish-purple. The grapes keep better and do not shatter so badly as the Olivette Blanche.

The *Flame Tokay* produces large bunches of large individual berries which adhere well to the cap stems. In America the variety is most highly prized when it has developed a brilliant red color. In certain of the hotter sections, it may attain maturity and fail to color sufficiently. The flavor and keeping qualities, however, are satisfactory. It is possible, therefore, that some of the markets of the Far East where green color is desired, might offer an outlet for such grapes. The *Ribier*, which is dark reddish-purple in color and only of medium quality, may have promise in the markets of the Far East because of the large size of its individual berries. This is especially true if it can be handled so that its berries will not shatter badly. The *Muscat of Alexandria* produces large bunches of large individual berries, white in color, with a marked Muscat flavor. The *Emperor* produces large berries, generally fairly resistant to handling injuries and adherent to the pedicels. The pedicels are strong and thick and the berries are firmly attached to them. The eating quality is very good.

Peaches and Nectarines.—Both peaches and nectarines are too delicate to be successfully exported, even to the nearest available ports where these fruit are admitted, i.e., Shanghai, Hong Kong, and Manila. The fruits bruise and discolor and the flesh becomes brown and loses flavor. The *Elberta* is considered the best commercially grown shipping variety, but it did not successfully withstand a shipment in

excess of 19 days when wrapped and packed in peach boxes in the usual pack. While this would normally enable the peaches to be delivered to Japan, this country at present has an embargo on peaches.

Two new peach varieties specially packed (see p. 54) supplied by the Chico Plant Introduction Field Station, harvested September 3, reached Shanghai in excellent condition on October 7, having been retained in cold storage pending the arrival of the refrigeration vessel. The two peach varieties were called *Ospreys Improved* and the *Goodmans Choice*. The comparatively excellent outturn of these fruits was no doubt due in a large measure to the careful special packing they received. Of the two peaches, the Osprey Improved kept the better and was in good marketable condition upon arrival in Manila, October 15.

The *Galopin* nectarine supplied by the Chico Station and similarly packed reached Yokohama in good condition.

Oranges.—The shipments of *Washington Navel* oranges from California are heaviest from November to March. During this period almost no *Valencia* oranges are shipped. As Valencia shipments increase, Washington Navel shipments decline. By the time Valencia shipments have reached a maximum, the Washington Navel crop is off the market. During April and May Washington Navel and Valencia oranges may both be shipped to some extent. The heaviest shipping period of oranges from California is from March to June, and the low point in shipment is in October.

The evidence indicates that temperatures of 36° to 38° F are satisfactory for carrying oranges under marine refrigeration. At lower temperatures brown spotting of the rind may result and the fruits lose quality and the skin may become dull in luster. At temperatures much higher than 38° F, the fruit may wilt badly and losses from blue mold may result.

Important factors in reducing blue mold are to have the oranges dry and free from mechanical injury of the skin and to store the fruit without delay. An additional factor in lessening blue mold under marine refrigeration is adequate air circulation to reduce pockets of high humidity within the packed containers.

While the number of boxes was limited there was no evidence obtained as to differences in keeping quality of Valencia oranges from Orange County between those Brogdex-treated and those untreated.

According to Granville Woodard, Assistant Trade Commissioner of the United States Bureau of Foreign and Domestic Commerce, during the months of October to January inclusive, Shanghai fruit dealers may stipulate the shipment of oranges from the Pacific Coast

to Shanghai by ventilated stowage, in order to reduce the freight charges. During the rest of the year, however, shipment is made under refrigeration, to lessen the risk of spoilage during the warmer weather.

The experience of the importers indicated it was perilous to ship either the Valencia or Washington Navel orange near the end of its season because of the greater hazard of rotting. The type of orange most acceptable in the markets of the Far East is one possessing good keeping qualities.

Lettuce.—Lettuce is in great demand by the American and European population in the ports of the Far East, especially in Shanghai and Manila. It has not been possible so far to ship lettuce with consistent success from the Pacific Coast to ports beyond Shanghai. At Manila and more distant ports there is generally from 50 to 80 per cent loss.

One of the principal causes of loss seems to be the slimy soft rot. The outer leaves become wilted, darken and blacken, become soft and slough away. The disease is characterized by a slimy and slippery condition of the affected parts and by an offensive odor. The slime results from a disease that may be caused by the fungus *Botrytis* and by a number of different bacteria. Frequently the inner portion of many heads can be utilized by pulling off and discarding the outer leaves. The tissues of the lettuce may be predisposed to slime by bruising of the leaves in handling operations. In transit it can be best kept in check by packing only healthy uninjured heads and by shipping under dry, cool conditions, preferably at a temperature of about 32° F.

Insufficient oxygen seems to cause the inner leaves of the heads to become dotted with rust-colored or dark spots.

INFLUENCE OF THE REGION WHERE GROWN ON THE EXPERIMENTAL CARGO

The processes of development of the fruit upon the tree may be so modified by the environment during the growing season that its responses under marine refrigeration are affected. Fruit from one region may differ in keeping quality from the same variety grown in another region, as was illustrated by the experimental cargo under observation. For the same reason, the same variety of fruit may differ in keeping quality from season to season. For example, many of the more important commercial varieties of apples appear to keep better if the weather, throughout the growing season and during the harvest

period, is not too hot and humid. Weather conditions some years seem especially favorable for the attacks of fungus diseases, rot organisms, and insects. Fruits so affected do not keep satisfactorily. Fruits may vary in time and rate or ripening during different seasons. Generally, when climatic conditions are such that the fruits ripen abnormally fast and early they do not stand distant transportation. The season during which the test trip was made appeared to be an especially favorable one, because it was cool and late.

Apples.—A relation exists between temperature during the growing season and subsequent development of internal browning of the Yellow Newtown apple (fig. 6, p. 34) as grown in part of the Pajaro Valley (Overholser, Winkler, and Jacob, 1923). When the mean temperature from June to September is relatively low, severe internal browning may be expected with prolonged retention under refrigeration; when the mean temperature for the same months is relatively high, little or no browning may develop.

The experimental cargo of Yellow Newtowns did not develop internal browning primarily because it was not held in storage enroute longer than a period of eight weeks, and secondly, because it was not kept at an average temperature in the refrigerated hold that was below 36° F. It has been determined, however, that if Yellow Newtown apples from the Pajaro Valley were harvested after a season of low summer temperatures, from old weak trees, bearing a light crop, were delayed in being stored, and when stowed in the ship were kept at a temperature as low as 30° to 32° F, internal browning might be expected to show up on arrival in the foreign markets. This would be particularly likely to happen with the last shipments of the season if they had been held at point of origin or elsewhere previous to loading at storage temperatures as low as 32° F.

There is an opinion among certain of the importers that apples grown in Yakima and Wenatchee districts carry better and keep longer than those grown in some of the California districts. During the experimental trip, however, all of the varieties grown in California carried nicely as far as Singapore. The one exception was some of the boxes of earliest harvested Gravenstein apples from the Sebastopol district, which developed some bitter pit (fig. 8) and shriveled appreciably enroute.

Pears.—A definite relation was observed between the region in which Bartlett pears were grown and their keeping quality enroute to foreign markets. It should be pointed out that the Bartlett unfortunately at best is not a good keeping variety, and hence does not lend itself to successful exportation to distant foreign markets.

It was determined as a result of the experimental shipment that Bartlett pears from the higher elevations of Sierra Nevada foothills of the upper Sacramento Valley kept the best of any of the lots; those from the Berryessa Valley ranked next in keeping quality, followed in order of keeping quality by Bartletts from upper Lake County and the Antelope Valley. The Bartletts from the lower Sacramento Valley, Solano, Alameda, and Santa Clara counties did not keep satisfactorily beyond Shanghai, and in this port there was some spoilage with certain lots from these latter districts. Manila was the farthest port, however, that even the better keeping Bartletts could be kept without danger of appreciable spoilage.

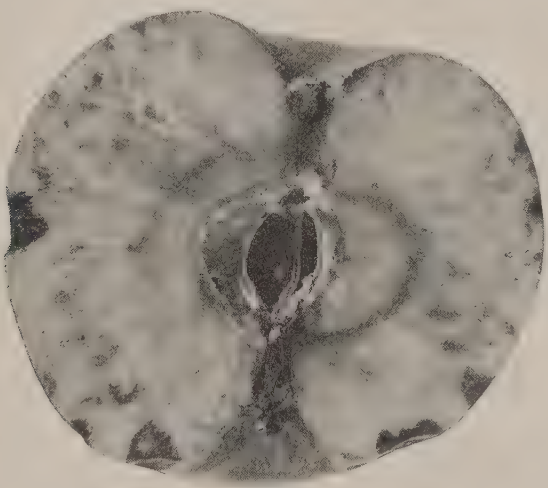

Fig. 8.—The Gravenstein apple showing bitter pit; the flesh is dry and brown just underneath the pitted area of the skin.

There were slight variations in the keeping quality of certain lots of other varieties. These differences, however, were not so marked as in the case of the Bartlett, and material was not available from so many sections. Furthermore, all the varieties except the Howell and the Clairgeau kept satisfactorily until the most distant port of Singapore was reached.

Plums and Grapes.—There was little consistent difference in the keeping quality of plums and grapes from the various sections. With these fruits, it was more a question of variety and method of packing. Some evidence was obtained indicating that plums from the cooler coastal, or bay regions, did not keep so well as did those grown in the

warmer foothill districts. It was observed that grapes from the southern part of the San Joaquin Valley carried better than the same varieties grown elsewhere, but the difference was not marked.

Citrus Fruits.—Importers have an opinion that oranges and lemons from Ventura County and grapefruit from the Imperial Valley carry more satisfactorily than those grown elsewhere. The various varieties in the experimental shipment all carried in good condition as far as Singapore.

Miscellaneous Truck Crops.—Several importers seemed convinced that the melons, lettuce, and celery grown in the State of Washington tended to arrive in better condition with less loss from spoilage than was the case with these products as grown in California. They agreed, however, that the quality of the melons, and the crispness and tenderness of the lettuce and celery was superior when grown in California.

INFLUENCE OF PACKING OPERATIONS ON THE EXPERIMENTAL CARGO

All containers of fruits and vegetables should be new and clean. The merchants of the Far East count the sale of the container as a part of their profits. The empty kegs or chests are used in the far eastern ports as containers for other products, such as frozen fish, onions, and potatoes. The Chinese merchant cannot so readily dispose of or receive as much for a dirty or soiled container as he can for a new clean-looking one. Hence, when a shipment is received with containers not clean-looking, the Chinese merchant demands from the fruit importer a rebate or 'squeeze' of 1 to 3 cents or more on each container.

When the Chinese merchant gets accustomed to a particular type of container he is suspicious of a different type and it is difficult to convince him that a new type is superior.

The labels on the package are a significant factor in the fruit business in Singapore and other Far East ports. The Chinese fruit dealers ask for fruit with a certain label, thinking the same grower furnishes the exporter with the same fruit. The label should be bright, even flashy, to command attention.

The variety name should be stamped on the box, as this will give the dealer an opportunity to call for the variety his experience indicates meets his needs.

Since the inspection and landing charges in Java are usually based on the number of boxes, it is advisable from this point of view to use the standard large containers. This cost, for example, for two half

pear boxes would be double that for one standard pear box. The fee charged by the inspector has been until recently one-half a guilder (about 20 cents gold) for each box, irrespective of whether the fruit is rejected or accepted. Recently the inspection fee has been reduced to 16 cents a package on week days.

Occasionally in the past it has been possible to get two half boxes or two containers strapped together and invoiced as one package, landed and inspected as one box in the port of Surabaya with no additional charges. Information was received that in all probability this would not be permitted in the future.

Weight of Fruit and Containers.—The Chinese fruit dealers of the Far East buy upon the basis of the net weight of the fruit rather than by the case or container. It is, therefore, essential to have the full net weight of the fruit in each container, as is stamped on the box. In addition, the number of fruits, their size, and of course, the variety should be stamped on the box. The importer sells to the wholesaler, and he to the retailer, and the latter to the consumer, by the pound rather than by the container or by the number of specimens. When the weight is short, through improper packing or shrinkage, there is generally a claim for a rebate and the label and the importer may suffer.

In several instances the fruit handlers complained of the fact that containers of fruit were occasionally received that had less than the net weight of fruit stamped thereon. There are three obvious ways in which this might happen, (1) insufficient fruit packed to begin with, (2) losses occurring through pilfering, and (3) losses occurring through transpiration of moisture and respiration of sugars and acids.

Each package of experimental fruit was weighed shortly after it was received. Omitting the special packages it was found that the standard containers varied widely in weight as a result of differences in the quantity of fruit packed. For example, it was determined that the gross weight of display lugs of Thompson Seedless grapes varied from 26 to 37½ pounds. In the first case insufficient grapes were packed in the container, while in the second case the grapes were packed so tightly that injury from crushing of the grapes resulted. The gross weight of kegs packed with Thompson Seedless packed in sawdust varied from 51½ to 58½ pounds. The net weight of fruit stamped on each of the lugs was the same, and this was also true in the case of the kegs.

The weight of apples and pears in standard boxes is dependent to some degree, of course, upon the extent of the 'bulge,' those with excess bulge weighing more than those with slack bulge. When the

bulge was approximately the same, boxes of small fruits tended to weigh more than those with large fruits because there was less total air space in the former boxes. The relation of bulge to weight is shown in table 21.

TABLE 21

THE RELATION OF BULGE TO WEIGHT OF BOXES OF APPLES AND PEARS

Species and variety	Height in inches		Size of specimens	Gross weight of box in pounds
	Top bulge	Bottom bulge		
Bartlett pears*	1⅝	1	165	58.0
	1½	½	180	53.0
	1¼	⅜	165	50.0
Gravenstein apples	1⁹⁄₁₆	¼	100	52.5
	⅝	None	100	51.5

* The boxes of wrapped pears were from same orchard and did not have pads top and bottom or 'side-liners."

To determine the variation in weight with size of specimens, 48 boxes, 12 each of four different fruit sizes, all having about the same bulge, were weighed. Three boxes each from four different sections were averaged for each fruit size. The data are shown in table 22. There was little difference between the boxes from different sections.

Loss from pilfering can be reduced by using strong, well-strapped containers and packing without an excess bulge, thus making the fruit less accessible to petty thieves or thoughtless individuals.

TABLE 22

THE RELATION OF SIZE OF SPECIMENS TO AVERAGE WEIGHT OF SIMILARLY PACKED STANDARD BOXES OF BARTLETT PEARS

Number of specimens to box	Average gross weight of twelve boxes
	pounds
90	50.9
105	52.0
120	53.1
180	55 3

To obtain an approximation of the loss in net weight from transpiration and respiration of the fruit, a number of containers were selected and weighed upon receipt and again after four to eight weeks under refrigeration. Representative data are shown in table 23.

To compensate, therefore, for loss in weight resulting from the metabolism and evaporation of water by the fruit, it would be desirable to pack about 5 or 6 per cent overweight of fruit or to stamp the

net weight correspondingly less, unless the tariff laws of some importing country should be violated. As would be expected, because of the protection afforded by the packing and package, there was comparatively little loss in gross weight with grape kegs.

TABLE 23

LOSS IN WEIGHT DURING SHIPMENT THROUGH TRANSPIRATION OF WATER AND RESPIRATION OF SUGARS AND ACIDS BY THE FRUIT

Species	Pack	Number of containers averaged	Original weight, average	Date of first weighing	Final weight, average	Date of last weighing	Loss in weight
			pounds		*pounds*		*per cent*
Grapes	Lugs	18	29.3	Sept. 9	27.8	Oct. 6	5.1
Grapes	Kegs	11	52.5	Sept. 9	52.0	Oct. 27	0.9
Pears	Standard boxes	21	55.5	Aug. 1	52.1	Oct. 6	6.1
		6	53.3	Sept. 11	50.5	Oct. 7	5.2
Plums	4-basket crates	7	31.7	Sept. 8	28.4	Oct. 26	5.7

Apples and Pears.—An excessive bulge on apple and pear boxes permits pilfering; fruit can be readily removed from each side of the bulge opening. The importers object to an excessive bulge in the box. Such boxes are certain to have a large percentage of badly bruised fruit. The stevedore, unless carefully watched, frequently piles fruit boxes on the bulge. When stowed with one bulge on the floor, if the bulge is excessive it projects above the cleats or dunnage at each end, with the result that the weight of the boxes stacked above is supported by the bulge. Furthermore, in stowing the cargo and in unloading at each port, the stevedores walk over the boxes and an excessive bulge catches the weight of the stevedores walking over them with a box of fruit in his hands. If the box is stowed on the side the bulge projects out and meets the bulge of the adjoining boxes with the result that the passage of cooling air currents from the refrigeration coils or air inlet ducts is obstructed or blocked. In Java they prefer a bulge of about ½ inch and not over ¾ inch. Pears from Australia arrived in Batavia packed in containers much like half lemon or orange boxes, except the top and bottom were made of material ½ inch thick; the boxes had no bulge and excelsior pads were used top and bottom. These pears showed no bruising.

To determine changes in the extent of the bulge which might result from loss of moisture and from yielding of the flesh of packed fruit at points of contact with adjacent specimens and sides of boxes, measurements were made of the bulge after packing and after four weeks enroute under marine refrigeration. Representative data are in table 24.

TABLE 24

THE LOSS IN EXTENT OF BULGE OF BOXES OF BARTLETT PEARS UNDER MARINE REFRIGERATION*

Bulge when packed		Bulge after 28 days under marine refrigeration	
Top	Bottom	Top	Bottom
inches	*inches*	*inches*	*inches*
1⅝	1	1	9/16
1¾	¾	1⅜	3/16
1½	½	1	⅛
1½	½	⅞†	⅛
1¼	⅜	⅝†	None

* These boxes did not have pads at top or bottom and had no side liners.
† These resulted in so-called "slack-packs."

Fig. 9.—Pear package in Kanagawa Prefecture, Japan. (Photo by Professor T. Miki.)

The Chinese trade seems to desire pears in half boxes. This is particularly true with the hotel caterers. A half pear box is more readily resold intact than is a standard box. The importers, however, prefer to handle the standard box of pears. Some eastern apples packed in barrels have been imported into the Philippine market. Barrel packing, however, is not particularly desirable because of the loss of freight space. The apple case commonly used in Australia is square, weighs 50 pounds gross and holds about one bushel.

The importers stated that before shipment to distant markets pear and apple boxes should be wired or metal-strapped to withstand the

Fig. 10.—Wagons of pear packages in Kanagawa Prefecture, Japan. (Photo by Professor T. Miki.)

Fig. 11.—Tamil stevedore from India. This type of labor is used in Singapore in unloading the fruit cargo. (Photo by Carl Spurlock)

ocean voyage and handling the cargo receives, and to lessen pilferage. The Chinese coolie of Shanghai and the Tamil coolie of Singapore (fig. 11) appears to be especially rough in handling the fruit containers during the unloading operations. The fruit received comparatively rough handling by the coolie stevedores at each of the ports. Pilfering by prying up the lid or by removing fruits from an excessive bulge of apple and pear boxes is a common practice.

Excelsior pads should be used both top and bottom to lessen bruising from rough handling. Boxes may be thrown or dropped several feet into place. A single rough treatment of fruit in excellent condition up to that time may result in a total loss. This loss might be avoided or greatly reduced by packing with less bulge, using excelsior pads top and bottom and possibly between each layer, using bevel edges and side liners, and if feasible double-wrapping each specimen—wrapping with one wrapper, and then again with a second wrapper.

It is false economy to grow fine-quality fruit and go to the expense of preparing it for shipment to a distant foreign port, without using every reasonable precaution to insure its arrival in excellent condition. The fruit is handled by coolies who are not only ignorant and indifferent, but also difficult to manage because of their temperament and the language barrier. The best method now available to circumvent their carelessness is to use a pack that will stand rough handling.

Grapes.—Grapes packed in 32-pound net kegs or in 32 or 22-pound chests with white sawdust appear most satisfactory for Shanghai. It is possible that grapes carefully handled could be expected to arrive in good condition as far as Shanghai when packed in Los Angeles or display lugs. Losses from rough handling are likely to occur, however, when so packed. Furthermore, pilfering by prying up the lid or by breaking and removing a piece of the slatted veneer top of lugs is a common practice. The lug should never be used as a container for grapes to be shipped as far as Java or Singapore. The Australian grape keg has 26 pounds net.

The Ribier and other varieties of grapes, while they carried packed loose in lugs to Manila, were not satisfactory upon arrival when thus packed, since the berries shattered badly when hung up for display. When packed with sawdust in chests or kegs, however, the berries adhered more satisfactorily to cap stems, and because of the large size of the individual berries the Ribier variety may have some promise, notwithstanding its dark-blue color. The lug is too light and is easily broken into for pilfering. It affords the grapes no protection from bruising.

During the last two seasons, the 32-pound net chest has been increasing in popularity. These chests are made of heavier material than the Los Angeles lug, and the grapes are packed in sawdust. The package, therefore, stands handling much better than the Los Angeles or the display lugs, and the sawdust in the chest helps to protect and preserve the grapes. Grapes are also exported in 22-pound chests packed in sawdust. The chests are preferred to kegs in that the former are cheaper and do not take up as much room when stowed in the hold. However, grapes are imported into Manila in kegs, and this package is at present considered more desirable than the drum. If it can be shown that there is a slight gain in the use of the drum its acceptance may be obtained. No difference was found in the keeping quality of grapes in drums and in kegs.

The 32-pound grape keg packed with sawdust is the acceptable package for Singapore. The dealers object to the drum and the chest. The lug is impossible to use successfully for such a long shipment. The dealers claim the drum gets dirty more readily than the keg, since when it is rolled the entire surface is in contact, while with the keg only the bulge is in contact and the hoops keep the staves from coming in contact with the dirt of the pier very much. While admittedly the drum has certain advantages, it is difficult to alter the opinions of Chinese dealers, and they believe the drum has little second-hand value.

Either the new flush-top keg or the old countersunk keg is acceptable, but the flush-top is preferred. The fruit importers in Surabaya and Batavia prefer the grape keg with the flush top to the keg with the countersunk top. The importers in Shanghai and Manila up to the present prefer the keg with the countersunk top, and definitely object to the flush-top keg. The bands should be of galvanized iron, because these do not rust or stain the staves and the keg keeps its new, clean appearance longer.

Several importers stated that they have detected some objectionable flavors imparted to grapes from white-pine sawdust used in grape kegs, especially with the Emperor variety. Spruce sawdust, on the other hand, did not impart any detectable flavor or odor to grapes.

Plums.—The ordinary four-basket crate did not prove to be a satisfactory container for the export of plums. The container is too fragile and breakage and pilfering is excessive. Furthermore, the plums are loose and roll about and become dislodged when the crates are stood on edge or upside down as they frequently are. Much basket-rim and crate-edge cutting results and mold and consequent spoilage rapidly follows. The rim and edge-cutting was reduced by

use of top collar shims and an excelsior pad between the last layer of plums and the top of the crate.

A somewhat more satisfactory container on the basis of protection afforded the fruit was a peach box prepared as follows: (*a*) Excelsior pads were placed top and bottom. (*b*) Corrugated side-liners, extending along each side from the lid to the bottom were inserted. (*c*) Only one layer of individually wrapped plums was packed. The pack can be made fairly snug by using more than one side-liner on each side and by using, if necessary, more than one excelsior pad on top, the number depending on the size of the plums.

On the basis of observations on response of the plums during the experimental trip, the most satisfactory package was the ordinary grape keg or drum. Layers of plums and sawdust are alternated until the keg is packed, the top and bottom layers being sawdust, of course. The lid is then snugly pressed into place. Each plum should be wrapped with one parchment wrapper, or double wrapped with two absorbent wrappers. Wrapping is desirable to furnish further protection to the plums, to isolate infected plums and lessen the spread of rot and to lessen possible cutting of the skin by the particles of sawdust. Plums of good inherent keeping quality, packed in this manner, were carried to Singapore in excellent condition. Parchment paper is better than the absorbent wraps because it does not soften and tear and thus lose its protective action, as the absorbent wraps sometimes do.

Peaches and Nectarines.—Peaches wrapped in absorbent paper, packed in peach boxes with sphagnum moss, with corrugated cardboard placed between the two layers and shredded moss dusted between the rows of packed fruit to furnish additional protection, carried best. There was less bruising and wilting, and the fruits were retained under refrigeration nearly six weeks. Nectarines similarly packed, however, absorbed objectionable flavors from the moss. Peaches may also be packed in grape kegs with sawdust as described for plums.

Melons.—Honeydew melons packed in a single layer in slatted crates and nested in excelsior absorbed objectionable flavor from the excelsior. Certain importers object to the use of excelsior as a packing for melons for this reason. They prefer shredded paper immediately about the melons and excelsior about the outside. Possibly the individual melons should be separately wrapped with parchment paper before they are nested in the shredded paper and excelsior.

If the melons protrude between the slats, edge cutting may result; therefore the slats should not be too far apart. Much of the damage

suffered by the experimental melon resulted from bruising and cutting, which might have been avoided by proper packing.

Citrus Fruits.—All citrus shook should be double and the boxes should be strapped. Double shook is required to withstand the journey and the handling and also to permit redistribution to various inland points from each port. Strapping also adds to the strength of the package. Furthermore, if the box is not strapped it leads to the suspicion that the container may have been repacked with lower-quality fruit. Finally, double shook and strapping reduces the pilfering on the dock.

In Manila there is a local practice of splitting the standard boxes of lemons into two half boxes. This has been accomplished locally at lower costs than could be done in the United States. During the last several years, however, shipments of half boxes have been received.

For oranges, many Australian exporters use a bushel box, which holds about 50 pounds, with from 80 to 180 oranges.

Lettuce.—Many types of packages and methods of packing have been tried, but the long-distance shipments of lettuce arriving in good condition have been rare. Conditions in the field may to a marked degree affect the shipping quality of the lettuce. Lettuce should not be harvested until the heads are mature and firm. The tops of mature heads have a somewhat silvery appearance and are lighter in color than the immature heads. Immature heads of lettuce wilt more readily.

Lettuce should not be cut for shipment after a rain or an irrigation when the field is muddy, or until the frost and dew have disappeared in the morning. When the plants are turgid with water, the leaves are crisp and brittle and break easily in handling. Lettuce that is slightly wilted is injured less in handling and packing, and carries better in transit; however, it should not be delivered to the packing shed in a badly wilted condition. When the packing shed is some distance from the field the crates should be covered with heavy cloth or canvas. Furthermore, the crate should not be filled too full in the field, since this favors crushing or bruising in hauling and handling when the crates are stacked on top of each other. It is advisable to place the heads in the crate with the stems up so as to permit the moisture in the heads to drain out.

While the loose, diseased, and damaged outside leaves should be trimmed off, not too many wrapper leaves should be removed, since this increases the danger of damage by bruising.

In preparation for shipment by rail to eastern states, three layers of heads are packed tightly in the crate with stems up, generally with

cracked ice between the layers. From 25 to 30 pounds of ice is used in each crate. This method did not, however, prove satisfactory for shipment under marine refrigeration. Enroute east by rail the journey averages from 9 to 14 days, but to certain oriental markets the journey may be more than twice that long. Before the market is reached the ice has melted and the refrigeration it supplies has ceased, and by making the lettuce wet and possibly by the mechanical injury, it has produced conditions favorable for the slimy soft rot. Also, since there is no means of draining it in the hold, it slops about and damages other perishables in adjacent containers.

With the experimental shipment the lettuce which carried best was prepared as follows: A crate of standard size made out of veneer wood and lined with parchment paper was used. Egg-style cardboard compartments were employed for the three layers of 12 heads each. Cardboard was placed top and bottom and between the layers. Each head of lettuce was carefully wrapped with light durable parchment paper and placed one in a compartment.

The lettuce should have as much of the base retained as is feasible. As the wrapped heads are placed in the cardboard compartments, clean, not too fine sawdust is sifted in around them and all of the space in the box is thus filled. The box, paper, and sawdust should be precooled to 30° to 32° F before packing, and the packing operation should be carried out in a room having a temperature of from 40° to 50° F. After packing the container should be immediately returned to a temperature of 32° to 34° F, and kept there until stowed in the ship's hold at a similar temperature. When discharged from the ship the lettuce should again be stored at a temperature of 32° to 34° F until ready for sale and consumption. This method, while the best of sixteen methods tried did not completely eliminate the losses. When lettuce is packed in tight boxes in sawdust it is necessary to open the container quickly when moved from low storage temperatures to room temperatures and to expose the lettuce to sufficient air. After six weeks under marine refrigeration, lettuce packed with fine sawdust in tight veneer boxes absorbed a noticeable sawdust flavor, even when it was wrapped in oil paper.

If the sawdust is too fine and powdery it cuts off the infiltration of oxygen and confines the carbon dioxide given off by the lettuce. For the same reason, oiled or waxed paper is apparently not as satisfactory as parchment paper. The sawdust must be free from splinters. Physical injuries and lack of oxygen are two factors which start deterioration. Insufficient oxygen favors leaf spotting. While

the increased cost is a serious factor, a substantial reduction in the 60 to 90 per cent loss now sustained in shipping to Manila might more than offset the increased cost of packing.

Celery.—The experimental lots of celery contained crates of several sizes packed in several ways. When the tops of the bunches were not severely trimmed and the bunches were packed in the open crates, the celery tended to wilt badly. Furthermore, the outer stalks of the bunches against the inside of the crate often showed mechanical injuries.

When the crates were lined with oiled or waxed paper, there was less wilting and shrivelling and the celery arrived in somewhat better condition. In the experimental lot which carried best, the top leaf area of each bunch of celery was severely trimmed and each bunch was separately wrapped with parchment paper and packed in the open crate lined with parchment paper. This reduced the wilting and lessened the mechanical injury and consequent drying out and discoloration of outer stalks. Trimming the tops gives a container a lower height and hence reduces freight cost. It is inadvisable to pack too tightly by squeezing in too many large-sized bunches to the crate. This excessively tight packing itself results in injury, and with rough handling the crate is more likely to break and fall apart. Several importers suggested packing only three or four dozen in a smaller crate instead of five dozen in the crate now used to lessen the likelihood of breakage, which frequently results with the larger crates. Care must be exercised in the use of oiled and wax paper to avoid the possibility of too complete an exclusion of fresh air from the packed celery.

SIZE OF SPECIMENS

There is much experimental evidence that oversized fruit cannot be retained so long at low temperatures as can specimens normal sized for the variety, particularly with apples and pears. The largest specimens seem more susceptible to bruises, attacks of rot organisms, and to rapid deterioration. In the case of certain varieties of apples the large specimens show more bitter pit than do the small. The observations made during the experimental trip tended to bear out this generalization.

On the other hand, large size apparently is desired by dealers in some of the ports. For example, in Shanghai importers stated that the Chinese desire large sizes of attractive fruit. It is apparently

difficult to dispose of small-sized fruits profitably. The Chinese fruit merchants of Shanghai prefer Winesap apples in relatively small sizes, but Yellow Newtown apples of the larger sizes are also popular.

The sizes of American apples largely in demand on the Manila market range from 138 to 216 per box. There is, however, a decided preference for sizes approximating 150's. Mr. Rohrer states that the use of tiers in the designation of sizes of apples is not extensive in the Manila market at present.

Information was obtained that buyers in Surabaya prefer apples of the size ranging from 135 to 175 to the box. In Batavia apparently somewhat smaller sizes of apples are in demand—those ranging from 163 to 216 to the box. The dealers in Batavia believe that the smaller sizes of apples keep better after a long shipment than do the larger sizes.

Advice received indicated that the size of the Gravenstein apples shipped to Singapore has been somewhat too large for the local demand. The sizes of apples most acceptable for the Chinese fruit merchants of Singapore are those from 125 to 163 per box.

The Chinese dealers in the ports throughout the Far East not only want large-size bunches of grapes, but they also want grapes with large individual berries, which adhere well to the cap stem and do not shatter badly. The practice is to display the grapes by suspending several large bunches, each on a separate string above the fruit stand.

About 90 per cent of the oranges imported into Shanghai are of the size 200 to the box, since the small Shanghai fruit shops can sell that size most readily and profitably. A limited quantity of larger-sized oranges are imported for the foreign residents. In the Manila market there is almost no demand for American oranges smaller than 176 to the box. When oranges of the size of 200's or smaller are brought into the Philippine market they usually sell at a loss. In Java, orange imports from California range in size from 125 to 252 to the box. The preference is for the medium size, since they sell by count in Java instead of by weight. When oranges are imported from California into Singapore, sizes of 150 to 176 to a box are desired.

Lemons of the size of 300 to the box are desired in Manila and Singapore.

DUTIES AND RESTRICTIONS ON IMPORTS AND COLD-STORAGE FACILITIES IN PORTS VISITED

The ports visited in connection with the experimental trip were Yokohama and Kobe in Japan, Shanghai and Hong Kong in China, Manila in the Philippine Islands, Surabaya, Semarang, and Batavia in Java; and Singapore in the Straits Settlements.

Japan

The harbor of Yokohama is about 4,570 miles from San Francisco and it requires, depending upon the weather and sea, about 14 to 16 days for the trips. The other port visited in Japan was Kobe, which is about 345 miles, or about 24 hours run by boat, from Yokohama.

Fig. 12.—Horizontal terrace (Tana) of Japanese pears in Kanagawa Prefecture, Japan. Grapes and peaches are grown on a similar trellis. (Photo by Professor T. Miki.)

Import Restrictions and Duties.—The importation of fresh apples, apricots, peaches, pears, plums, prunes, and quinces from the United States into Japan is prohibited. Citrus fruits may be imported after inspection in Japan. There is no embargo at present upon grapes or avocados. A certificate of origin of the fruit is necessary in order to get the preferential rates of import duties where such rates prevail

as, for example, with lemons. Otherwise the commercial invoice and ocean bill of lading are sufficient. There are no customs surcharges nor internal revenue nor sales taxes to be paid on fruits imported into Japan.

Since 1924, there has been a 100 per cent ad valorem duty on all fruits that are admitted, except on certain citrus fruits. Lemon fruits from the United States, for example, which are entitled to the benefits of the Japanese conventional tariff, are subject to an import duty of about 47 cents per 50 pounds. The Japanese common unit of weight is the picul, equal to 10 kin. The kin is equal to about 1.3 pounds avoirdupois. The 100 per cent ad valorem duty is calculated on the wholesale market value at the time of declaration to the customs. This would be the original cost, plus the insurance and the freight charges.

There are no regulations as to the packing, labeling, and marking of fresh fruits.

Cold-Storage Facilities.—The cold-storage facilities for fruit in Japan are limited. It was stated that when the quantity of fruits and vegetables imported justified the expenditure capital could be interested to provide cold storage.

In Yokohama one cold-storage company has about 6,120 square feet of storage space. This is the only space available in Yokohama. In Tokyo, about 12 miles north of Yokohama, there are a number of cold-storage plants. One of the largest maintains about 22,000 square feet of refrigerated space.

In the port of Yokohama the perishable cargo for Tokyo is discharged from the ship to a lighter or barge and towed to Tokyo. The cargo is then transferred by coolies to a 'go-down' or to a cold storage in the city. This requires 2 to 4 hours.

The standard temperature for storage of oranges is 37° F. In Yokohama the rate per case of oranges (about 2.5 cubic feet) is about 25 cents a month when not bonded. If bonded the rate is 20 per cent more. In Tokyo the rate for storage of fresh fruits is on the basis of 1 cent per day per cubic foot required.

In Yokohama the coolies necessary for handling the fruit in and out of the refrigerated chambers must be supplied by the depositors. If the quantity is small, however, the cold-storage company attends to the handling free of charge. In Tokyo the handling of case goods in and out of the refrigerated chambers is done under the control of the cold-storage company. The hire for the coolies for 3 cubic feet and less is 3 cents, and for each additional 3 cubic feet the cost is 1½ cents.

A plan was underway for construction of a cold-storage warehouse in the Customs compound in Kobe, with the intention of opening the same for trade before the summer of 1930. At the time Kobe was visited, however, there was no cold-storage accommodation in any of the berthing wharves. The refrigerated goods are taken from ocean steamers into ordinary covered lighters. In all cases, previous arrangements are made with cold-storage warehouses so that the goods may be taken to shore refrigerators with minimum of delay. The quantity of refrigerated goods imported to this port is small and therefore does not justify construction of refrigerator barges.

The prevailing rates for the storage of fruits and vegetables are shown in table 25.

CHINA[2]

Shanghai is about 722 miles from Kobe and the traveling time by boat is about 2½ days. Fresh fruits and vegetables are imported into China from the Pacific Coast through Shanghai and Hong Kong, which have regular refrigerated-boat service for the transportation of perishable commodities. Hong Kong, which is under British control, is not a port of China politically.

In Shanghai gangs of Chinese coolies aid in stevedoring the cargo from the ship to the 'go-down' or warehouse. Each two coolies use a bamboo pole about 8 feet long and 3 inches in diameter, with a rope sling suspended from the center (fig. 13). The containers are lifted up from the holds of the ship in slings by means of the electric winches and lowered over the side of the ship to the dock. The boxes are placed in slings suspended from the bamboo poles by the coolies. The coolie is rough in his handling of boxes and the containers must be strong, durable, and well-strapped to withstand the handling they may be expected to receive in Shanghai.

There are about 15,000 Americans and Europeans in Shanghai and a concentration of wealthy Chinese. It is this minority of the population that has means which enable them to buy California fruit.

Importation Requirements.—The ordinary commercial invoice or ocean bill of lading is required upon shipments of fruit to China before the authorities will pass the cargo, but no other papers are required. There are no regulations as to the labeling and marking of packages for the Shanghai markets. Since no preferential rates are applied to imports from any country, it is not necessary to mark

[2] For a further discussion, the reader is referred to: Moomaw, C. W., and M. L. Franklin. Markets for American fruits in China. U. S. Dept. Agr. Dept. Cir. 146:1–27. 1920.

Fig. 13.—Chinese coolies on the pier in Shanghai, China, with their bamboo poles. The pieces of cargo are slung on one pole and carried by two coolies or with two poles by four coolies. (Photo by Carl Spurlock.)

TABLE 25

RATES FOR COLD STORAGE OF FRUITS AND VEGETABLES IN KOBE, JAPAN

Description	Unit	Term	Cost in yens*	
			Up to 200 cu. ft.	Over 200 cu. ft.
	VEGETABLES			
Onions, potatoes, tomatoes, greens, melons, egg plants, peas, tubers and bulbs	1 cu. ft. per day	Up to 30 days	0.012	0.010
		Over 30 days	0.010	0.008
Onions, cabbages	1 package per day	Up to 30 days	0.050	0.040
		Over 30 days	0.040	0.030
	FRUITS			
Apples, grapes, pears, apricots, persimmons, oranges, lemons, loquats	1 cu. ft. per day	Up to 60 days	0.012	0.010
		Over 60 days	0.010	0.008
Cherries and strawberries	1 box per day	Up to 15 days	0.005	0.004
		Over 15 days	0.004	0.003
Fresh Chestnuts	10 Kwan (appr. 83 lbs.) per day	Up to 60 days	0.030	0.025
		Over 60 days	0.025	0.020
Apples for fixed term	Up to 100 boxes, per box	3 months	1.000	Over 100 boxes, each additional box 0.800
		6 months	1.500	1.200
Chinese chestnuts	1 package per month			1.200
Water melons	1 package per 3 days			0.150
	over 3 days for every additional day			0.020

* The yen is equivalent to about 50 cents in United States gold.

goods as to country of origin. As the duty is based on net weight, the packing has no bearing and may, therefore, be such as will permit the fruit to be delivered in the best condition. There are no regulations as to the sanitary inspection of fruits in Shanghai.

Import Duties.—The information obtained was to the effect that the duty on fresh fruits (with the exception of apples, lemons, and oranges) coming into Shanghai is 10 per cent ad valorem. That is, 10 per cent of the value as determined by the invoice plus insurance and the freight. The importer usually pays the duty and charges the customer for it together with the other costs. A surcharge of 5 per cent of the duty is collected as wharfage and other dues. The rate of duty upon fresh apples is about 26 cents per 50 pounds, upon fresh lemons about 24 cents per 100 specimens, and upon fresh oranges about 43 cents per 100 pounds. Information from the trade indicated that on all fruits coming into the Chinese wharf for delivery to Shanghai, there is a 2 cent 'squeeze' attached to getting the goods through the 'go-down.' This goes to the wharf police and avoids delays in getting shipments through the 'go-down' and also excessive pilfering.

Cold-Storage Facilities.—According to information furnished by the representative of the Bureau of Foreign and Domestic Commerce of the Department of Commerce, there are about fifteen cold-storage plants in the consular district of Shanghai that are equipped with refrigerated space adapted to the retention of fruits and vegetables. The space available varies to a great degree between the different plants, but the total is estimated as being in excess of 1,850,000 cubic feet.

In addition, there are several individual concerns, such as the large hotels and food handlers, that have made provision for the temporary retention of fresh fruits and vegetables for their own use or for sale to customers. These individual firms have made no provision for long refrigeration of large quantities at any one time, but they lessen the losses of perishables held between the arrivals of refrigerated vessels. Their purchases may be from the ship's stores, or on an order they have placed with a local importer or placed direct.

The average charges for refrigeration vary from 10 to 12 cents gold per box per month to about ½ cent United States gold per pound or fraction thereof per month. There are some plants engaged primarily in meat packing or egg-product manufacturing, which in out-of-season periods have cold-storage space available and rent it for irregular periods of time at rates below those quoted.

Insurance is obtainable for goods in cold storage for both fire and deterioration risk, but for imported fruits and vegetables the cost is prohibitive.

THE PHILIPPINES

The total population of the Philippine Islands is more than 12 millions. The foreign population is about 65,500 of whom about 50,000 are Chinese. While the Americans and other people of the white race desire California fruits and vegetables, it is claimed that the Chinese and the native population in the larger cities, especially Manila, offer the greatest market for California fruit.

The peso is the unit of value of the currency. It is upon a gold basis and has an equivalent value of 50 cents in United States gold. A peso is equal to 100 centaves or centimos.

Importing Methods.—About 95 per cent of the fruit and vegetable importing business in the Philippines is handled by the Chinese, on a somewhat limited capital. The Chinese buy their fruit from the importer for cash on a prearranged contract. The merchant carries his customers until the periodical Filipino pay-days, and then buys more produce. Since the Chinese merchants must sell their merchandise quickly because of their limited capital, and since fruits and vegetables are perishable commodities and hence cannot with safety be long retained, this may tend to break the market and establish an unprofitable price for a time in case of temporary oversupply.

The importation of California fresh fruits may be conducted through banks in California and in Manila. The grower or shipper in California usually receives 75 per cent of the price quoted in Manila, when the fruit is delivered to the dock in San Francisco. The bank in Manila holds the documents and papers until the goods are paid for by the Chinese merchants. The merchants are always ready to pay the bank so as to maintain their credit. When the bank in Manila has collected the entire amount due, the California shipper receives his remaining 25 per cent.

There is a pyramid tax of 1½ per cent each time a sale is made within the Philippines. The fruit is sold direct to the consignee through the bank to avoid the payment of the 1½ per cent tax on this first transaction.

Much of the importation of fruits into the Philippine Islands is conducted on an indent basis. The local indent agent in Manila takes orders from the Chinese, Filipino, or other merchants, who in turn sell to smaller dealers and market and street vendors in quantities varying from half a case to several cases. It is not deemed advisable

at the present time for American exporters of fresh fruit to sell direct to small dealers. It seems preferable that business be done through the established firms having offices or connections in the United States as well as in Manila.

If direct exportations are made there should be no question as to the reliability of the Chinese dealer, and such exportations should be on the basis of cash in the United States, backed by letter of credit without recourse.

Importation Restrictions or Requirements.—Fruits from the United States are admitted duty free into the Philippine Islands, provided they are shipped direct under a through bill of lading. To effect customs clearance, commercial invoices must be furnished in duplicate and must contain an accurate description of the merchandise itemized therein, showing the quantity, value, weight, marks, number of packages, and place of destination. The original and duplicate invoices must have the following certificate: "I hereby certify that the above described articles are the growth, product, or manufacture of the United States, or its possessions, and that no drawback of import duties has been or will be claimed thereon, and that this invoice is true and correct in all particulars." This certificate must be signed on both original and duplicate by the consignor and both invoices should be mailed to the consignee for filing with the customs entry pertaining to the importation.

The boxes should be marked to show the country of origin. If the outside of the box is marked to show the quantity of contents, such marks must tally exactly with the contents as found upon inspection, or delivery will not be made until the marks are changed to conform to the facts.

Perishable merchandise may not be deposited in a bonded warehouse. If it is not immediately entered for consumption or transshipment it will be sold at auction after not more than 3 days' notice, according to the urgency of the case.

Fruit in the Philippines is sold on a weight basis.

There is no duty upon fruit imported from the United States into the Philippine Islands. Fresh fruit arriving in Manila is inspected by the Bureau of Agriculture. The landing charge from the dock to destination is 15 cents gold for each container. Including the inspecting and obtaining of clearance papers for the shipment, fruit is generally not on the dock over 2 hours before it is taken to its destination in Manila.

Facilities for Handling the Cargo.—Manila is provided with a modern electrically equipped pier of the Insular Government. Manila,

in contrast with most other markets of the Far East, has fairly adequate cold storage, although during the period of maximum receipts of imported fruits and vegetables the available space is well utilized. There is the possibility of additional facilities being built when justified.

Fig. 14.—Filipino women in front of a railway station bargaining for locally grown fruits and vegetables. North of Manila, P. I.

The rates charged by the cold storage for fruits and vegetables to be kept at temperature from 32° to 38° F, as required, are fixed by the Public Service Commission on the basis of space occupied. The rates per cubic meter (35.3 cubic feet) are as follows:

TABLE 26

Space occupied	Rate per cubic meter	
	Per day	Per month
Less than 1 cubic meter	$0.140	$4.20
1–15 cubic meters	0.115	3.45
15–30 cubic meters	0.095	2.85
30–150 cubic meters	0.075	2.25
Over 150 cubic meters	0.060	1.80

The minimum charge is for one cubic meter for one day. The rates just listed have a discount of 10 per cent.

The storage facilities elsewhere in the Islands are limited. Cebu, with a population of 75,000, has an ice-making capacity of about 30 tons a day.

Java[3]

Surabaya, is about 1,625 miles south and east of Manila, and including about two days' stop at Cebu and Opon, a little over seven days in time from Manila. In the tropics a large canvas tent is erected upon the deck to keep the direct sun out of the opened refrigerated holds (fig. 1), and the fruit is quickly moved into the shade of the warehouse after discharge upon the dock and then conveyed into cold storage with minimum delay.

Fig. 15.—Javanese coolies removing fruit from aeroplane sling to two-wheeled truck in Surabaya, Java.

The stevedores in Surabaya handle the perishable fruit cargo fairly carefully in unloading it from the refrigerated ship (fig. 15). This is in marked contrast with the method in Shanghai, for example. There is, however, considerable pilfering of the fruit.

Fumigation.—Each ship that docks in any of the Java ports must show a certificate of fumigation within the last 6 months. If this cannot be produced the Dutch government sends tugs alongside the ship equipped to fumigate with sulfur dioxide, either from compressed cylinders of the gas or by burning the sulfur. The refrigerated holds

[3] The reader is referred to Bliss, Don C. Markets for fresh fruit in the Netherland East Indies. U. S. Dept. Commerce Trade Information Bul. 587:1–12.

are not fumigated, but the cargo of fruit may suffer from leakage of the sulfur dioxide into the fruit holds.

Importation Regulations.—With certain exceptions[4] "all shipments of living plants (or living parts of plants), fruit and seed from abroad, ... to the Dutch East Indies, ... , must be accompanied by a certificate from the country of origin, in which certificate it is stated by the government expert of that country that the shipment is free from diseases and pests.

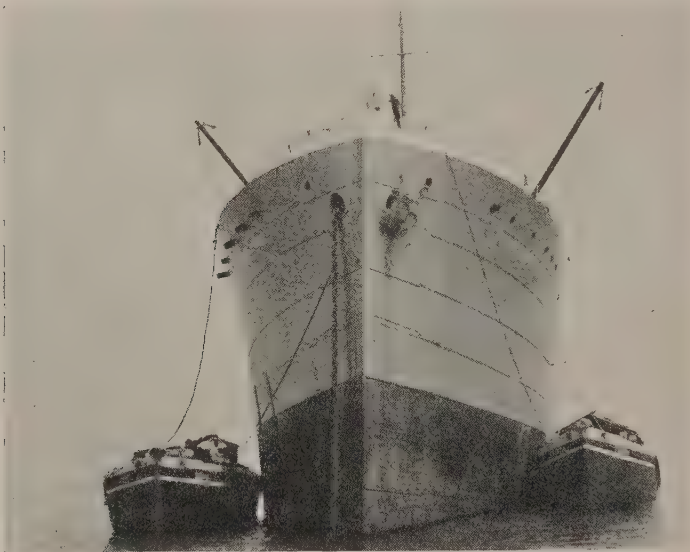

Fig. 16.—At Semarang; because of shallow water it is not possible to dock. The cargo is transferred to lighters.

"For parcel post the certificate must be attached to the customs-declaration, for letters and samples it must be put into the envelope with the letter or sample, for goods it must be sent to the importer or his proxy in the harbor where the inspection is to be effected.

"Fresh fruit must be inspected at Tandjong Priok (harbor of Batavia) Medan (Belawan-Deli), Semarang, Soerabaja (Surabaya), Makassar, Palemburg, Panghalpinang, Benghalis, Ponteanah, Samarinda, Talalean, and Balilepanan."

[4] Abstract from Ordinance of the Governor General of Netherlands, East Indian Number 26, September 27, 1926, and of the Decree of Director of Agriculture, Industry and Commerce, Number 9760/A.Z. November 3, 1926. Issued by the Institute of Plant Diseases, Buitenzorg, Java, November, 1926.

Potatoes from the United States must be accompanied by a certificate as mentioned in the first paragraph, "and furthermore by a statement of the government expert, that the potatoes are free from wart-disease (*Synchytrium endobioticum*) and that they are grown at least 500 meters distant from any field which is considered to be infected with this disease."

Of the plants excepted, certain vegetables only are of possible interest to California horticulturists, provided they are destined for consumption, as follows: beets, cabbage, carrots, endive, garlic, lettuce, onions, and spinach.

The plants which are free and need no certificate should be sent separately from those which are subject to control and which must be accompanied by a certificate. On sacks or boxes containing material which is free, the names of the contents must be clearly indicated.

It was stated that the inspection certificate given by the Agricultural Commissioner of the City of San Francisco fully meets the requirement of the agricultural authorities in Java who are charged with the inspection of fresh fruit imported into that territory. The certificate issued jointly by the United States Department of Agriculture and the California State Department of Agriculture is not satisfactory to authorities in Java, since it does not contain the clause, "free and clean from insect pests and fungus diseases."

It was pointed out by several fruit importers that the identifying marks on the certificate, the invoice, bill of lading and the manifest and the mark on the package or container of fruit must be the same. There should be no additions or subtractions on any one, but they must conform throughout. Otherwise the objection may be raised by the inspector that the certificate does not apply to this particular lot of fruit since the marks do not correspond. This calls for a delay, arranging for a special inspection through the headquarters in Buitenzorg, and additional costs. In the meantime the fruit may spoil before it can be moved to cold storage or be disposed of.

Import Duty and Inspection.—The duty is 12 per cent of the c.i.f. (initial cost, the insurance cost, plus the freight) invoice, plus ¼ of 1 per cent of the duty to support statistics tabulation. In addition there is a landing charge of 4 per cent of the c.i.f. invoice, and small harbor dues.

Even though a proper certificate showing the fruit to be free from insects and diseases is submitted, the fruit is inspected. It was stated that about 5 per cent of the boxes were examined by the inspector. A fee of 14 cents is charged for each box passed, whether the contents are in good condition or not. The importers object to the dock-

ing of the ship and discharge of the fruit cargo on a Sunday or on holidays. The fruit inspectors are not on duty then, and a special request must be made for them to appear on the dock. The charge per box on Sunday and holidays for inspection is 80 cents gold, and in addition it is generally necessary to pay taxi charges from the inspector's home to the dock and return, amounting to about $2.50 gold. One dollar of United States gold is worth about 2.40 florins or guilders.

Fig. 17.—Fruit market of apples, grapes, and other fruits imported from California, Australia, and China, in Batavia, Java.

Facilities for Handling Fruit Cargo in Batavia.—The fruit for Batavia, Java, is of necessity discharged on the dock at Tandjong Priok, the harbor, some 6 miles away from Batavia. It took only about 3 hours after the fruit was discharged from the ship to truck it to Batavia and to have it in cold storage again. The truck and coolie charge from the harbor to Batavia is about 12 cents a box.

The shortage of cold-storage space is more acute in Java than in Singapore. There are fewer cold-storage plants in Java. In Surabaya there is cold storage for between 4,000 and 5,000 boxes of fruit. The rates approximate about 2 cents a box per day. In Batavia the cold-storage space will take care of between 5,000 and 6,000 boxes. The daily rates are about the same as in Surabaya, and the monthly

rate approximates 50 cents a box. In Semarang, there is storage space for about 150 boxes but the rates are high. In some of the interior cities, a few dealers have their own cold-storage boxes for temporary retention of perishable commodities. The temperatures at which most of the fruit rooms were maintained were somewhat high, averaging about 40° F.

Fig. 18.—Javanese market of native fruits in Batavia. The two bunches on the left in the foreground are the mangosteen; the two baskets in the center are the mango.

There are no refrigerator cars available in Java, hence facilities for distribution of perishable fruits are inadequate. The two distributing cities are Surabaya and Batavia. Surabaya supplies the cities of Djocjakarta, Malang, Solo, Majelang and others. Batavia supplies fruit to Buitenzorg, Meester-Cornelis, Bandeong, and other cities.

Singapore

The entire Malay Peninsula does not have much more than 20,000 Europeans, one-half of whom live in Singapore. The Chinese population offers the biggest market for California fruits; at present they take about 90 per cent of the quantity imported. About 80 per cent of the fresh fruit imported into Singapore is handled by the Chinese

dealers. There are between 75 and 100 Chinese fruit and vegetable stores in Singapore. They all deal directly with the fruit importers.

Facilities for Handling Fruit Cargo.—Two large cold-storage plants in Singapore have at present cold-storage space for approximately 5,000 and 2,000 boxes of fruit, respectively. In addition an ice company has space for about 1,000 boxes. Certain firms handling food have comparatively small cold-storage boxes cooled by mechanical refrigeration for temporary retention of their own retail stocks. This storage space in the interior will take care of about 2,000 boxes of fruit.

Fig. 19.—Malay, Chinese, and Tamil coolies unloading fruit in Singapore. The fruit is removed from the aeroplane sling and carried one package at a time into the 'go-down.'

One cold-storage company is adding to its refrigerated space sufficient storage room for between 4,000 and 5,000 boxes. Furthermore, it is building mechanically refrigerated boxes in some of the interior towns and cities of the Malay Peninsula north of the island of Singapore. These are used to retain small lots of fruits temporarily for the retail trade, after they are trucked or shipped by refrigerator car from Singapore. Some of the places where these small cold-storage depots are located are Johore, Penang, Ipoh (Kuala Lumpur), Malacca, Seremban, Klang, Taiping, all on the peninsula of the Federated Malay States.

The cold-storage rates for fruit are 15 cents for the first week or fraction of a week and 10 cents per week thereafter. No reductions are allowed upon storage of large quantities. The cold-storage business has been somewhat of the nature of a monopoly, and the Chinese dealers feel they are compelled to place at least a portion of their

orders for fresh fruit with the cold-storage company, in order that they may be able to get cold-storage space when they need it. The cold-storage interests of Singapore are different from those in the United States in that they buy and sell perishable commodities, and thus import considerable quantities of fresh fruit.

The refrigeration engineers in Singapore attempt to keep the temperature for fruit storage at about 36° F, not below 34° F, and not above 39° F. In the case of apples and grapes, the fruit might be kept more satisfactorily at temperatures several degrees lower, about 33° to 34° F, provided the temperature control is sufficiently accurate.

Fig. 20.—Icing refrigerator cars in Singapore. The ice is chipped on the ground and tossed up by one coolie to be placed in the bunker by another coolie. (Photo by Carl Spurlock.)

The Chinese fruit dealers are convinced that cold storage provided by air circulation over coils in a bunker room and conveyed by ducts to the storage room is preferable for fruit to that provided by direct refrigeration from coils hung in the cold-storage room.

There are a few small iced refrigerator cars which can be iced and loaded with fruit and sent to cities in the interior. In icing the cars, the ice blocks are brought out one at a time from the ice-storage room by several Malay coolies and dropped to the ground at each end of the cars. Several coolies break the ice block up into small pieces and then toss these pieces up to a coolie standing on top of the car who catches it and drops it piece by piece through the open hatch into the bunker at each end of the car (fig. 20). Modern trucking vans are used to distribute the fruits to marketing stores nearby.

TABLE 27

THE SEASONS OF SHIPMENTS OF FRUIT FROM AUSTRALIA

Month	Fruit	Variety
January	Apricots	
	Peaches	
	Plums	
	Apples	
	Pears	Williams' Bon Chretien (Bartlett).
February	Apples	King David, Jonathan, Cleopatra, Five Crown, Granny Smith, McIntosh.
	Pears	Williams, Howell, Packham.
	Peaches	
	Plums	
March	Apples	Jonathan, Granny Smith, Cleopatra.
	Pears	Howell, Packham, Cornichon.
	Grapes	
	Plums } (possibly)	
	Peaches } (possibly)	
April	Apples	Granny Smith.
	Pears	L'Inconnu.
	Grapes	Ohanez.
May	Apples	Granny Smith
	Pears	L'Inconnu.
	Grapes	Ohanez.
	Oranges	Navels.
June	Apples	Granny Smith.
	Pears	L'Inconnu.
	Oranges	Navels.
	Grapes	Ohanez.
July	Apples	Granny Smith.
	Oranges	Navels or Valencia.
	Pears (doubtful)	
August	Apples (doubtful)	Granny Smith.
	Oranges	Late Valencia.
September	Oranges	Late Valencia.
October	Oranges	Late Valencia.
November	Oranges	Late Valencia.
	Apricots	
	Cherries	
December	Oranges	Late Valencia.
	Apricots	
	Cherries	
	Plums	

AUSTRALIAN FRUIT SHIPMENTS TO SOUTHERN ASIA

Australia sends fruit to the Malay Peninsula, Java, and other parts of Asia in considerable quantities. The season of harvest is different from that of the United States, so that both countries rarely send the same fruit at the same time. One sort of fruit from California therefore competes with another sort from Australia; apples and early Navel oranges from California will reach this market in competition with Valencia oranges from Australia. Table 27 shows the time of year when various fruits are shipped from Australia.

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